TERMINAL FORECAST REFERENCE FILE

Dover Air Force Base, Delaware

TERMINAL FORECAST REFERENCE FILE

DOVER AIR FORCE BASE

DELAWARE

PREPARED BY DETACHMENT 5, 15TH WEATHER SQDN

8TH WEATHER GROUP

AIR WEATHER SERVICE, (MATS)

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SECTION I. LOCATION AND TOPOGRAPHY OF DOVER AFB, DELAWARE

LOCATION AND TOPOGRAPHY

OF

DOVER AIR FORCE BASE, DELAWARE

1. Coordinates and Elevation

Latitude 39° 08" North, Longitude 75° 28" West. Elevation - 28 feet above sea level.

2. Geographic Location of the Station

Dover Air Force Base is located near the center of the State of Delaware, about three miles west of the Delaware Bay, thirty-five miles east of the Chesapeake Bay, and near the northwest end of the Delmarva (Eastern Shore) Peninsula. It is open to the Atlantic Ocean, about 25 miles southeast, down the Delaware Bay.

A "fall-line" runs from near Richmond, Virginia, to near Washington, Baltimore, Philadelphia and on to New York City, east of which elevations do not exceed 400 feet above mean-sea-level. Dover is situated some 40 miles east of the fall-line on the flat, frequently marshy, coastal plain. The entire Delmarva Peninsula is under intensive cultivation, the farms being interspersed with salt marshes and small patches of woods, mostly scrub pine. The communities are small and agricultural, rather than industrial.

Locally, salt water marshes exist between the Delaware Bay and the Base from a point north of the Base through east to the immediate south; a narrow river flows south-southeastward from the city of Dover, four miles northwest, into the marsh to the south passing the Base about a mile to the west. This is a tidal river and it is bounded by salt water marshes. Dry grounds exist to the north-northwest only. See Figures 1-1 and 1-2.

The local terrain is so flat that there is no up nor down-slope motion. However, on a micro-scale, the Base is situated on the southern end of a very slight ridge (i.e., the Base elevation is 28 feet and is surrounded, except to the north-northwest, by tidal water salt marshes) from which there is some cold air drainage at night under no-gradient conditions. This cold air drainage is sufficient, frequently, to keep the Base free of ground fog while the surrounding marshes are covered with thick radiation fog. This is especailly true over the marsh to the south, over which aircraft must pass at a hundred feet or so on final GCA approach to runway 01.

3. Air Polution Sources

Basically, the Delmarva Peninsula is populated with truck and dairy farms and small communities which exist on an agricultural rather than an industrial economy. The nearest industrial smoke pollution areas are forty miles to the north near Wilmington, and sixty miles to the west, in the Baltimore area. These have no appreciable effect on local visibility.

Locally, Dover, four miles to the northwest and Milford, fifteen miles to the south, do not have industrial plants sufficient to create a smoke problem. However, about 1/2 mile southwest of the main entrance, there is a small dump which is newly openod; this dump, up to now (March 1962) has not proven to be a problem from the visibility or pollution standpoint.

4. Physical Location of Weather Station

The physical location of the Weather Station is actually in two separate sections.

a. The station proper is located in the MATS Terminal Building (T-501). This is the administrative and forecasting section, along with the observers who directly support the forecasters. The instruments and equipment utilized are the teletypes, facsimile machines, the AN/APQ-13A radar set and the ML-2 Barometer.

b. The second location, the representative observing site, is located between runways 010 and 310 in Building T-1307. The actual room is a glass enclosed tower, which houses the recording units of the AN/GMQ-2A ceilometer (an AN-GMQ-10 transmissometer, and the AN/GMQ-11 Wind Recorder. The ML-3 Barograph, ML-102D anaroid barometer, the SAGE teletype and the Electro-writer, are also in the tower. The observing units for the ceilometer, transmissometer and wind gauge along with the instrument shelter, which houses a ML-24 psycrometer, and the ML-17 rain guage, are in representative locations outside of the building. The representativeness of our observations is very good; however, the visibility is hampered to the southeast because of a hangar and because of hangar and apron lights at night.

c. Surface observations are representative of the immediate runway complex, however, they may not be representative of conditions in or about the runway approachs. This is especially true of approaches on runway 19 and 31 which are partially over water area of the Delaware Bay. Whenever low and ragged ceilings exist, ceilings are generally lower on the approaches to 19 and 31, than are measured near the center of the field. All other parameters are representative.

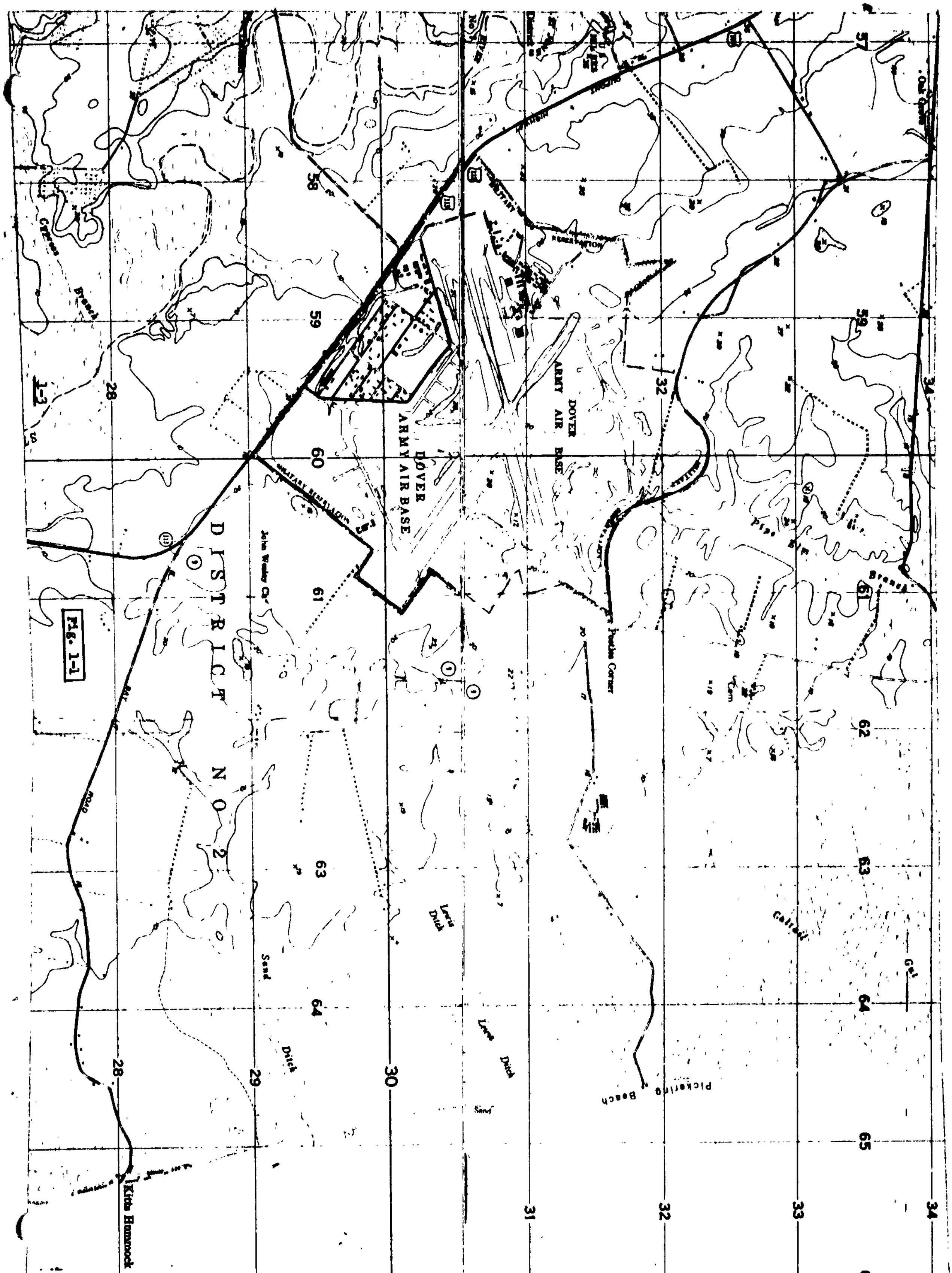

DOVER ARMY AIR BASE
DOVER AIR BASE
MILITARY RESERVATION
DISTRICT NO 2
John Wesley Ch
Pipe Elm Branch
Lewis Ditch
Sand
Ditch
Pickering Beach
Kitts Hummock
Cypress Branch
Fig. 1-1

Fig. 1-1

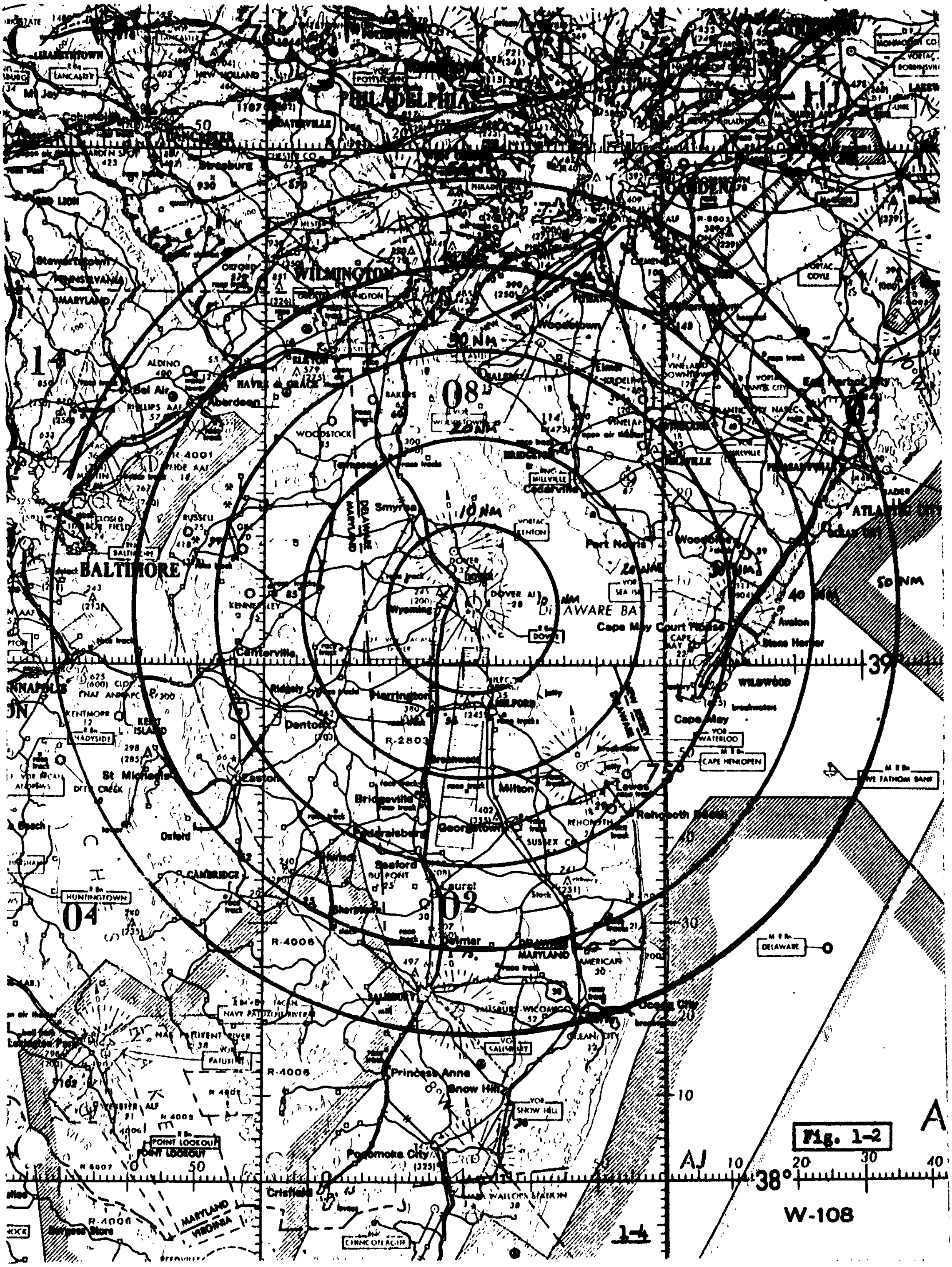

PHILADELPHIA
WILMINGTON
BALTIMORE
DOVER
Smyrna
Harrington
Milford
Georgetown
Seaford
Salisbury
Princess Anne
Snow Hill
Pocomoke City
Cape May
Wildwood
10 NM
20 NM
30 NM
40 NM
50 NM
08
02
04
39°
38°
AJ
W-108

Fig. 1-2

SECTION II. WEATHER CONTROLS

WEATHER CONTROLS

1. INTRODUCTION The Gulf Stream with its attendant warm water turns to the northeast off the Delmarva Peninsula. Between the Gulf Streams and the coast there is considerable upwelling of cold water. The position of the Gulf Stream and the amount of upwelling vary with the direction and intensity of the surface air flow over the local coastal area. With an established westerly or offshore flow, the Gulf Stream moves somewhat to the east of its normal position and becomes slightly cooler and there is more upwelling along the coastal area; with a several hundred mile onshore air fetch the Gulf Stream is much closer to the coast and considerable of the upwelling disappears. In addition, the water of Delaware Bay is colder than the coastal water seven to eight months of the year. The Bay will freeze over about once in twenty years.

From the above, it can be inferred that easterly to southeasterly overwater trajectories originating over or to the east of the Gulf Stream flow over increasingly colder water to the coast and for the greater part of the year on up the Bay to the Base; and as a result there will be cooling and condensation of the moisture laden air as it moves to the coast and the Base. This is true between October and May and with a weak southeasterly gradient, fog will occur on the coast and inland to well beyond Dover. With a stronger flow - in excess of about eight knots, some turbulent mixing occurs and a stratus ceiling of a hundred feet or so will exist, slightly higher during diurnal heating and commonly going to dense fog at night during nocturnal cooling.

During the summer months, fog is essentially non-existent up the Bay from the coast as a result of this cause; however, stratus ceilings of several hundred feet are common at night burning off two to three hours after sunrise. (This is dependent upon the sky condition above the stratus, with an upper or middle overcast, the stratus can hold in all day.) The typical year round synoptic situation for this fog-stratus condition is for the east-west axis of the Bermuda High to be found to the north of Delaware with a five hundred mile or more over-water trajectory from the east or southeast. See Figures #2-1 and 2-2 for sea-surface water temperatures off the coast. Referring to these figures, it is obvious that an air trajectory from the north-northeast to northeast is parallel to the isotherms and no cooling will occur while a trajectory from the southeast gives maximum cooling with a resultant "no fog" or "fog" forecast.

Due largely to the influences of the Gulf Stream and the Delaware Bay, mild winters and relatively cool summers are usually observed at Dover Air Force Base.

2. SUMMARY OF SEASONAL WEATHER CONDITIONS

WINTER: Cold fronts pass the station on the average of once every five days. During periods of strong zonal flow, fronts will move through the Dover terminal on the average of once each three days. Cold front weather will sel seldom produce ceilings below 2000 feet and visibilities less than 3 miles in showers. The warm front, on the other hand, generally produces low ceilings, poor visibilities and steady rain or snow. The warm front is difficult to forecast due to the fact that the Appalachian barrier is conductive to the stagnation of a cold pool or air over the coastal plains. Because of this, the warm front remains quasi-stationary along the Appalachians and low ceilings and poor visibilities may prevail for an extended period. As a rule, the arrival of a Pacific occlusion will result in clearing conditions. This situation is not limited to the winter season, but is also applicable to Spring and Summer. A case study of this type of situation is discussed in Section IV under Special Synoptic Studies.

The Hatteras Low affects Dover Air Force Base much the same as a warm front, resulting in low ceilings, poor visibilities, steady

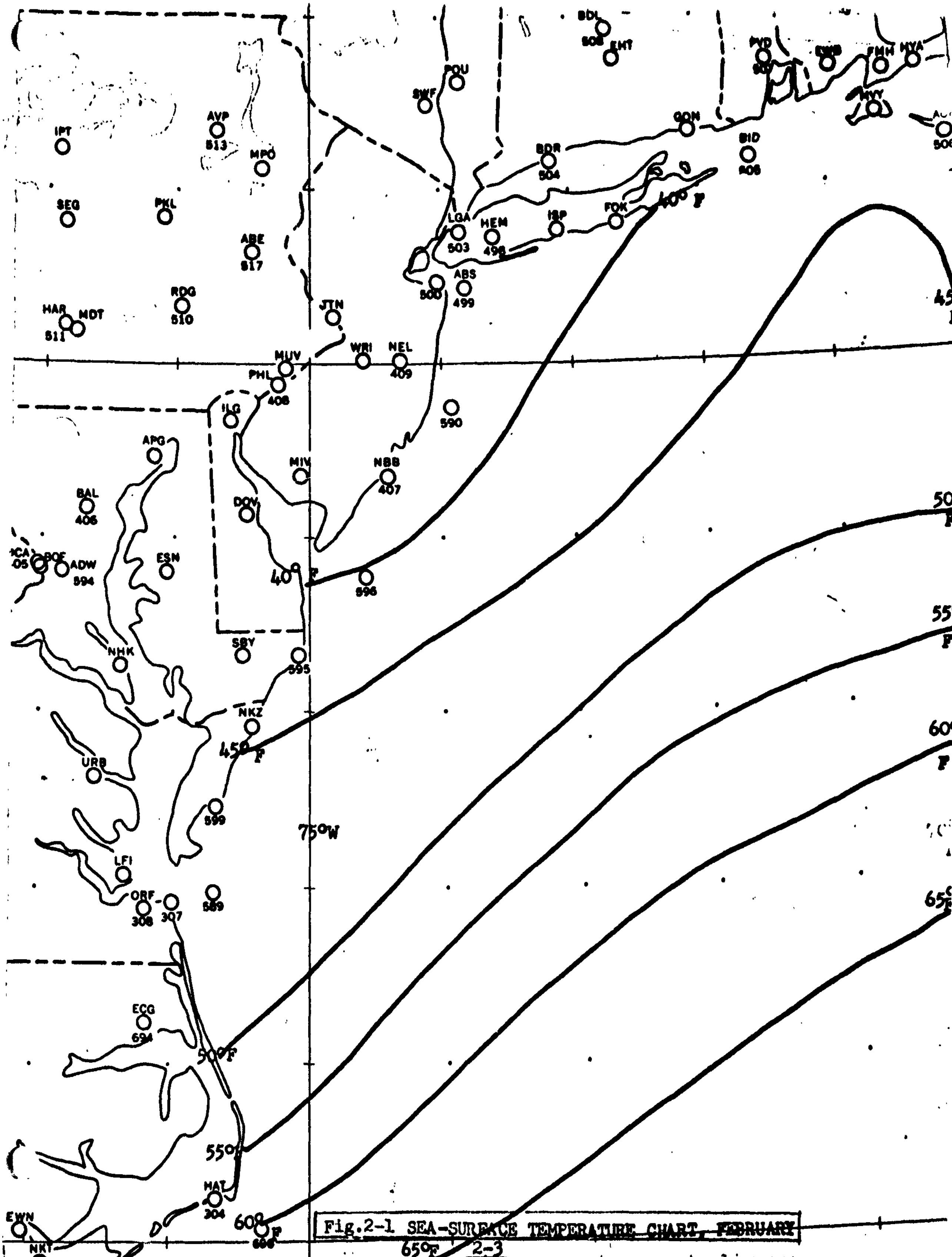


Fig.2-1 SEA-SURFACE TEMPERATURE CHART, FEBRUARY

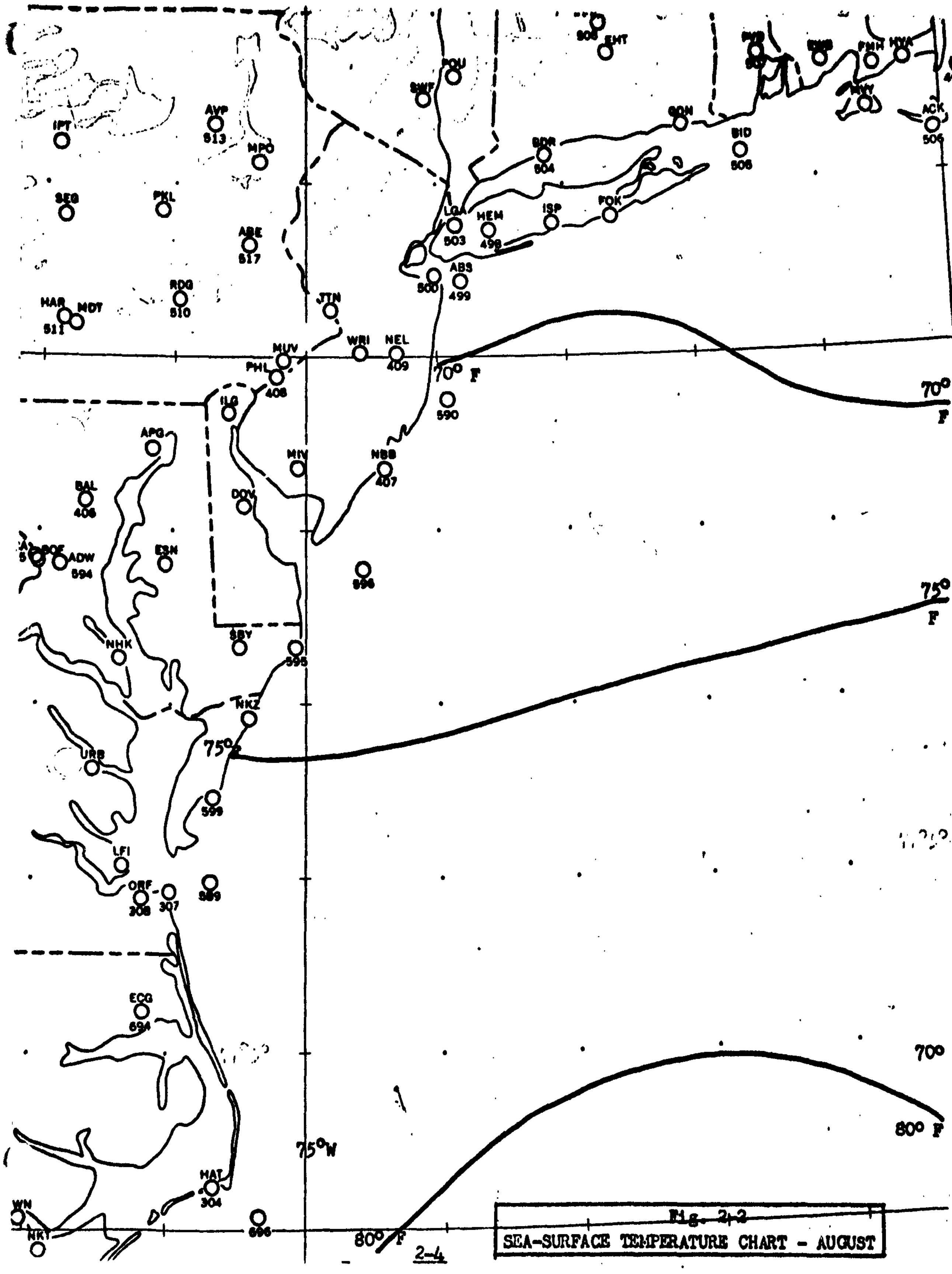


Fig. 2-2
SEA-SURFACE TEMPERATURE CHART - AUGUST

type precipitation and gusty surface winds. Gusts up to 50 knots are not uncommon with a strong low pressure area. Low pressure areas which move northward across the coastal plains generally produce the strongest surface winds at Dover with wind directions east to east-northeast. Gusts over 35 knots are likely with this type. If the low is off the coast, generally northeasterly surface winds of less than 35 knots are the rule. With this type, however, the possibility of snow rather than rain is greater. Clearing conditions occur as the low moves north of Dover, however, gusty surface winds up to 35 knots may continue for another 24 hours.

SPRING: During this season, the surface pressure gradients are weak and fronts diffuse and often difficult to locate with any degree of certainity. Thunderstorm activity increases considerably during the latter part of spring. A slight increase in frequency of early morning fog also occurs during this season. The major forecasting problem lies in predicting the location of the surface front relative to Dover and the attending low level flow pattern. Low ceilings and poor visibilities are the rule with easterly flow. Good visibilities prevail with southwesterly through northerly flow except when wind velocities are under 10 knots following a weak cold front passage.

SUMMER: Thunderstorm activity reaches its peak during this season. A high frequency of evening thunderstorms occur with maximum frequency in mid-July near 1900L. Frontal activity occurs on the average of once every seven days. Cold fronts are usually of the Pacific type resulting in thunderstorm activity and pre-frontal squall lines. Occasionally, a cold front will pass Dover from the north ("Back Door Cold Front") resulting in below average temperatures for this time of year. (It is this type of front that most often breaks a persistent heat wave over the northeastern seaboard.)

FALL: During this season, cold fronts pass the station on the average of once every seven days. As in the other seasons, these cold fronts do not produce prolonged or significant weather conditions. Precipitation is in the form of rain showers with conditions seldom less than 2000 feet and 3 miles. Thunderstorm activity decreases rapidly reaching minimum frequency by the end of the season.

Late summer and early fall is the hurricane season. On the average, one hurricane per season will pass close enough to the Dover Terminal to produce gusty surface winds up to 35 knots. Statistically, winds of hurricane force or higher can be expected once each eighteen years.

3. MAJOR SYNOPTIC FEATURES

The following pages contain illustrations and discussions of the major synoptic features which control the local terminal weather. No attempt has been made to type these situations other than to indicate the season in which the feature occurs.

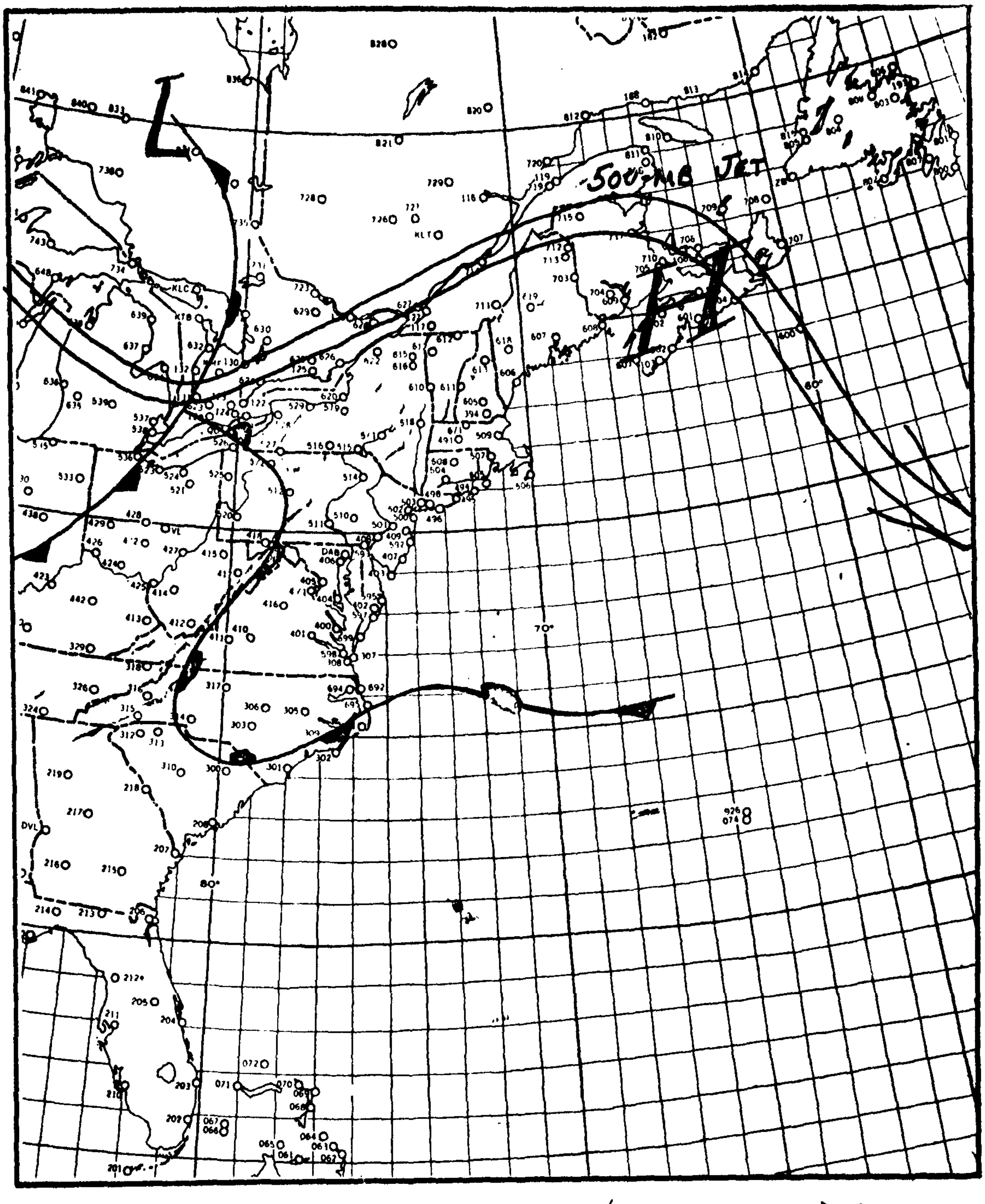
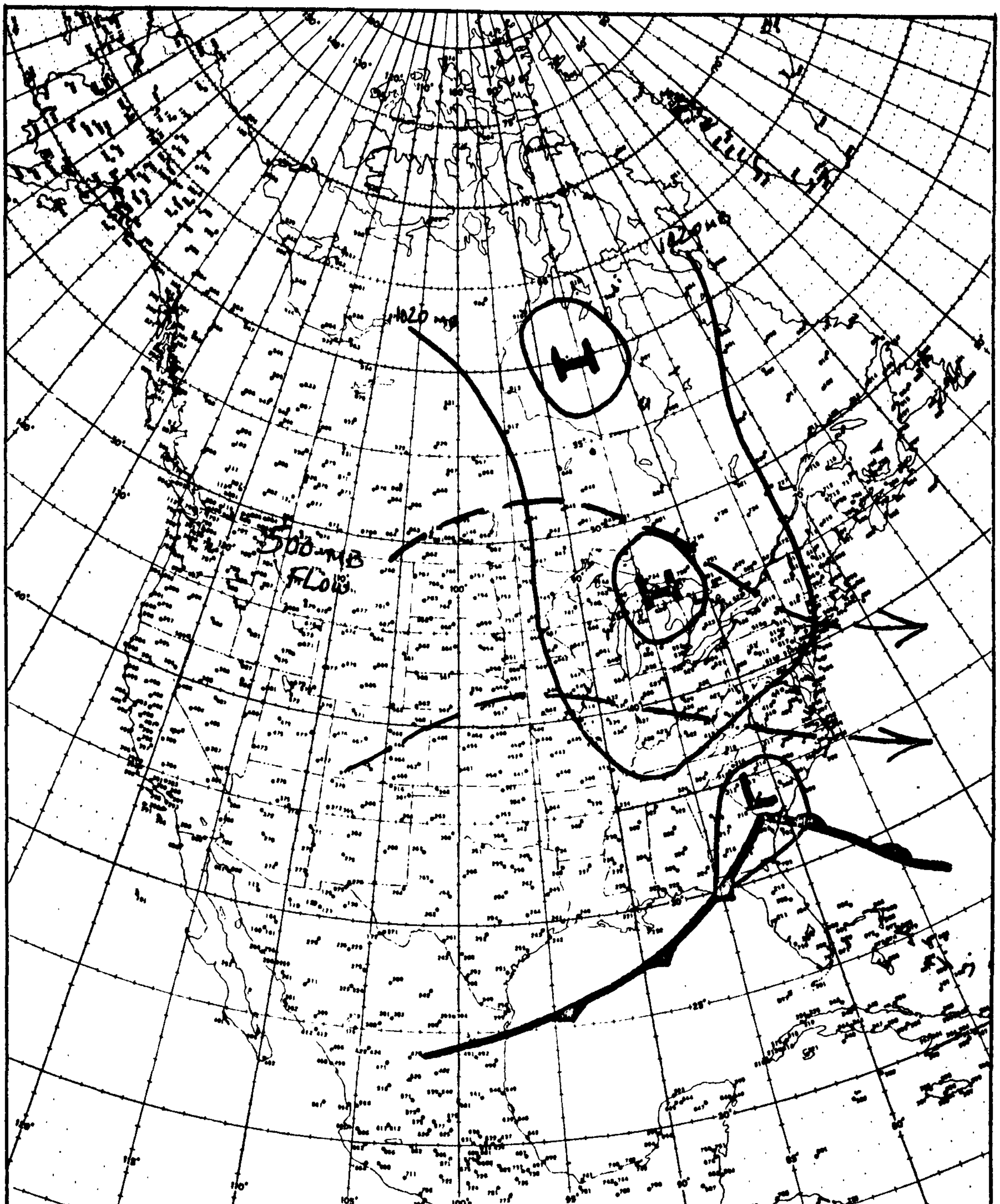


Fig. 2-3

Figure 2-3

<u>FALL THROUGH LATE SPRING</u>: This pattern represents a typical warm front situation which occurs during the period fall through late spring. The warm front often takes on an odd configuration, but generally a shallow dome of cold air persists over the Virginia - Carolina area causing the warm front to be quasi-stationary along the eastern slopes of the Appalachians. Minor waves often form in the vicinity of Cape Hatteras. This situation produces widespread fog, drizzle and stratus over Carolina, Virginia and east of the Appalachian range as far north as New York State. Freezing drizzle or rain will occur if surface temperatures are near or below freezing. Ceilings along the coast (and at Dover) will vary from 400 to 800 feet with visibilities 1 - 3 miles in fog and drizzle. Ceilings further inland will be lower. The forecaster must examine this situation very carefully, less he forecasts the warm front to pass the Dover area. Generally, conditions do not improve until the major front from the west occludes and passes the Dover terminal.



PSWC 1

LEGEND:

Fig. 2-4

——— ——— → 500-MB FLOW

—————— SURFACE

Figure 2-4

LATE WINTER - SPRING: A persistant high located over Hudson Bay with a secondary high located over the Great Lakes and surface lows forming over Texas move erratically across the northern half of the Gulf Coast states passing off the coast near Hatteras without intensification. With west to northwest flow at the 500 mb level, clouds and precipitation will be confined to the immediate vicinity of the surface low. As a rule, precipitation will not reach Dover. The only cloud cover over Dover will be broken to overcast middle and high clouds, and in some cases only high clouds depending on position of the 500 mb jet. The heavy middle and high clouds are found to the south of the 500 mb jet and north of the surface low. If a confluent zone exists to the north of the surface low, clouds and precipitation will extend ahead of the surface low to the approximate center of the confluent zone at the 500 mb level.

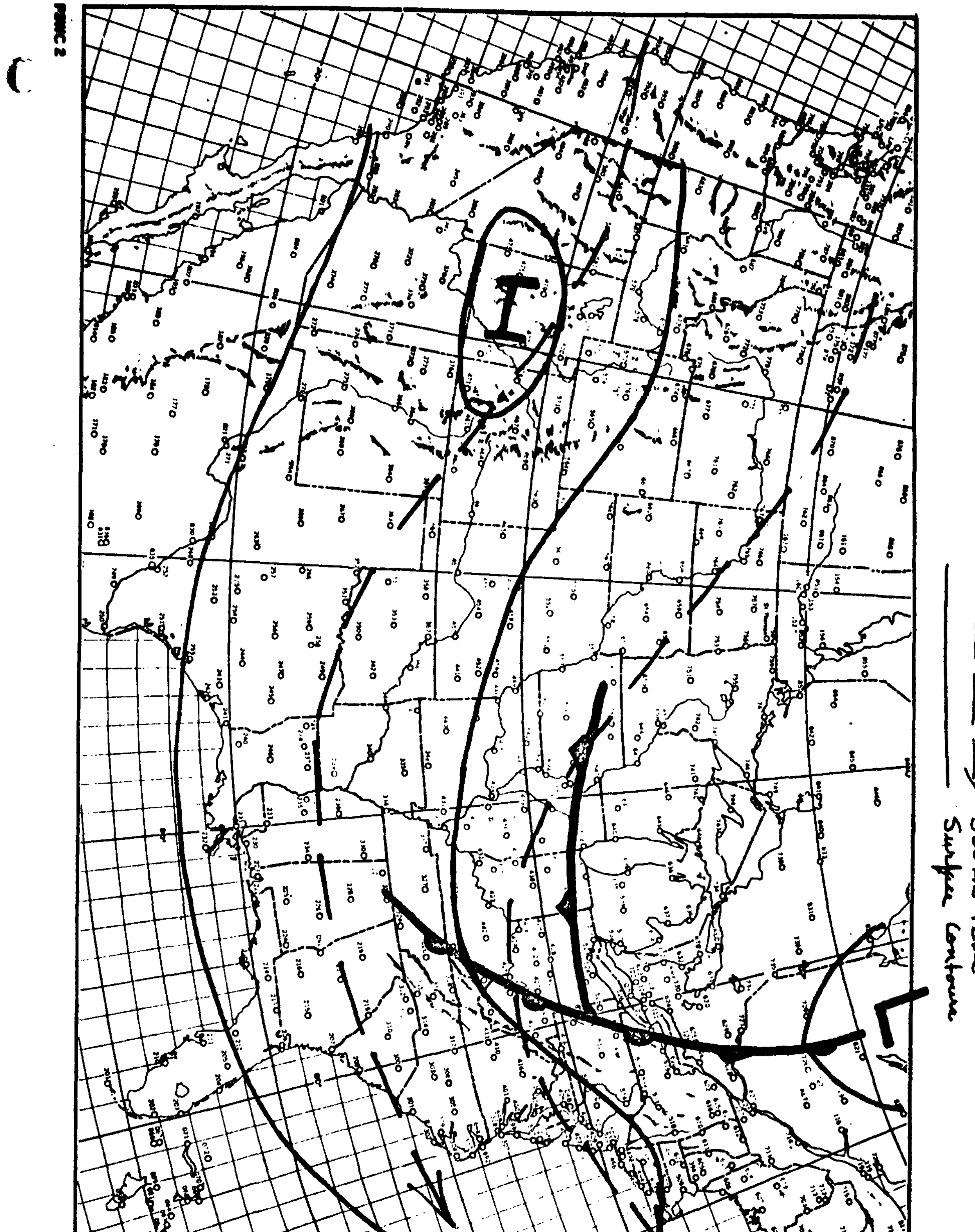
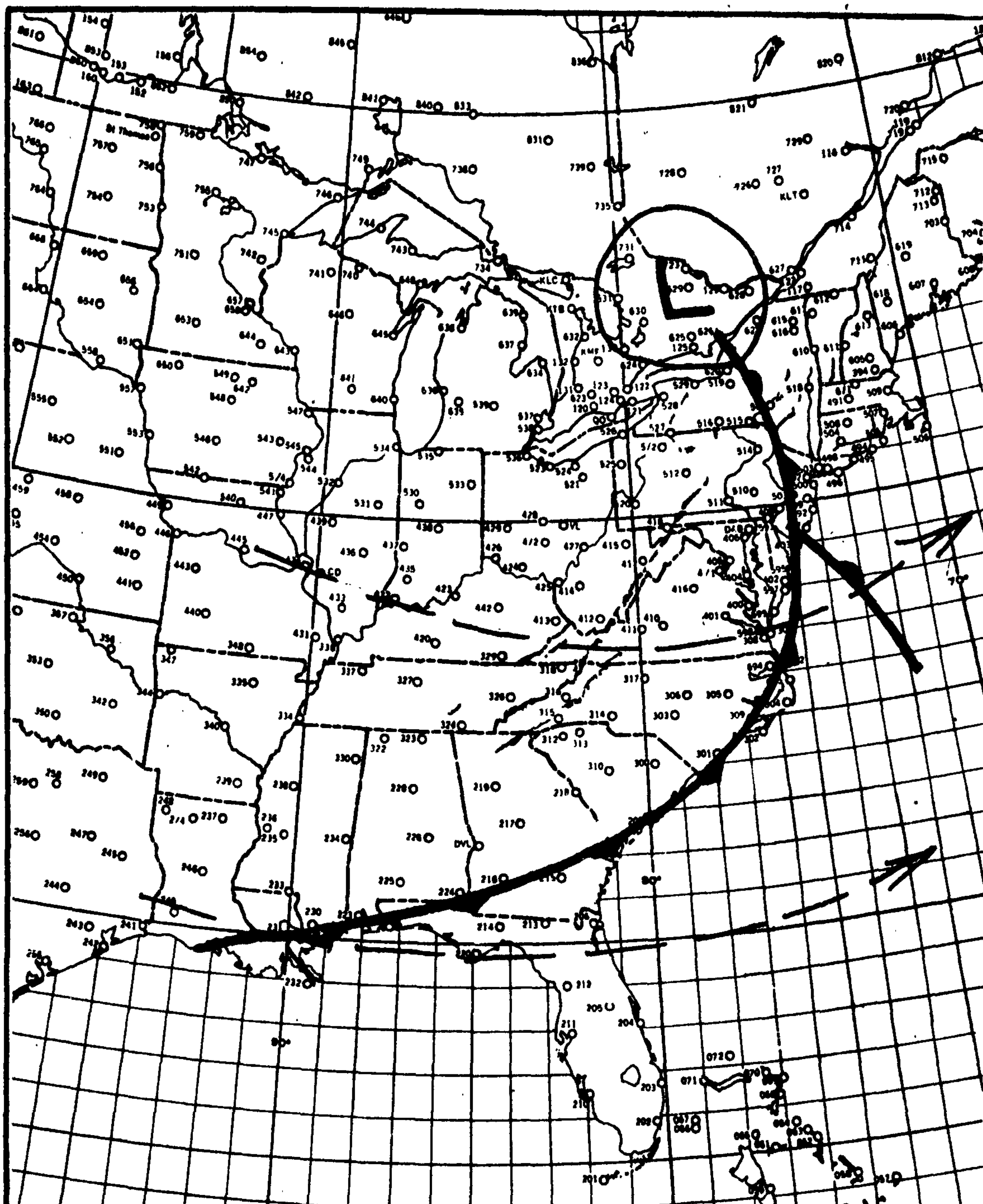


Fig. 2-5

Figure 2-5

LATE FALL - EARLY WINTER: A meridonal jet stream with major trough in the Great Lakes' region and a quasi-stationary low centered in the Gulf of Alaska from which lows are fed. These lows track northeast across Labrador to a deep upper low centered near the tip of Greenland. Frontal passages over the Delaware region are weak or the fronts remain to the north blocked by the mP high. There is no weather of consequence in the Dover area. The east coast "Indian Summer" is related to this pattern. Generally, fair weather prevails at Dover with gusty southwest surface winds in advance of the weak frontal systems.



PSWC 6

LEGEND:

Fig. 2-6

– – – – – → 500-MB FLOW

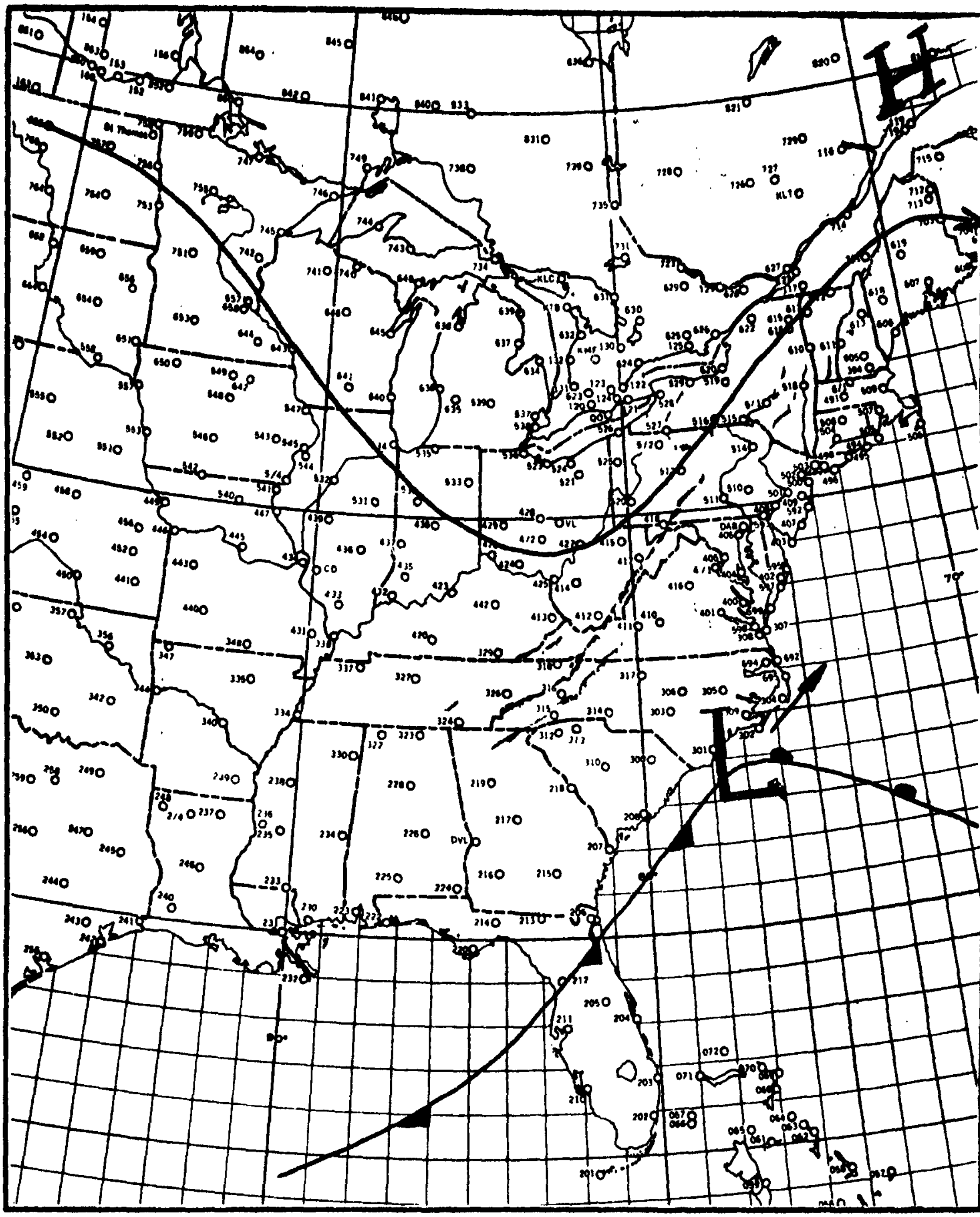
———————— SURFACE

87-0784

Figure 2-6

FALL AND SPRING:

The major trough is in the mid-west with the 500 mb jet generally south of Delaware. The trough is usually shallow and therefore wave formation in the southern plains or Gulf area is rare. Frontal systems move at moderate speeds and pass Dover at intervals of 3-5 days. Weather lies in a narrow band along the front with ceilings of 2000-4000 feet in rain showers occurring with frontal passage at Dover. In-flight visibility will generally be on the order of 1-3 miles in showers. In advance of the front, ceilings of 800-1000 feet and visibilities of 3-5 miles in haze may occur during the early morning hours depending on available moisture and surface wind direction. Generally, southeasterly flow is favorable for early morning stratus.



PSWC 6

LEGEND:

Fig. 2-7

⟶ 500-MB FLOW

87-0754

Figure 2-7

<u>WINTER</u>: The mean 500 mb trough lies over the Mississippi or Ohio Valley region with southwesterly flow over the eastern seaboard. A high pressure center is quasi-stationary over the Maritime Provinces or the Newfoundland region. Surface waves develop in the Gulf or along the Georgia-Carolina coast and move northeastward and deepen. Dover receives most of the winter's snowfall from this type low. Gusty northeasterly winds also occur with this situation and therefore, the forecaster must give serious consideration to the affects of snow and blowing snow on surface visibility. As surface waves pass Dover, clearing generally occurs, but gusty surface winds may prevail for as long as 36 hours depending on the speed and direction of movement of the storm center.

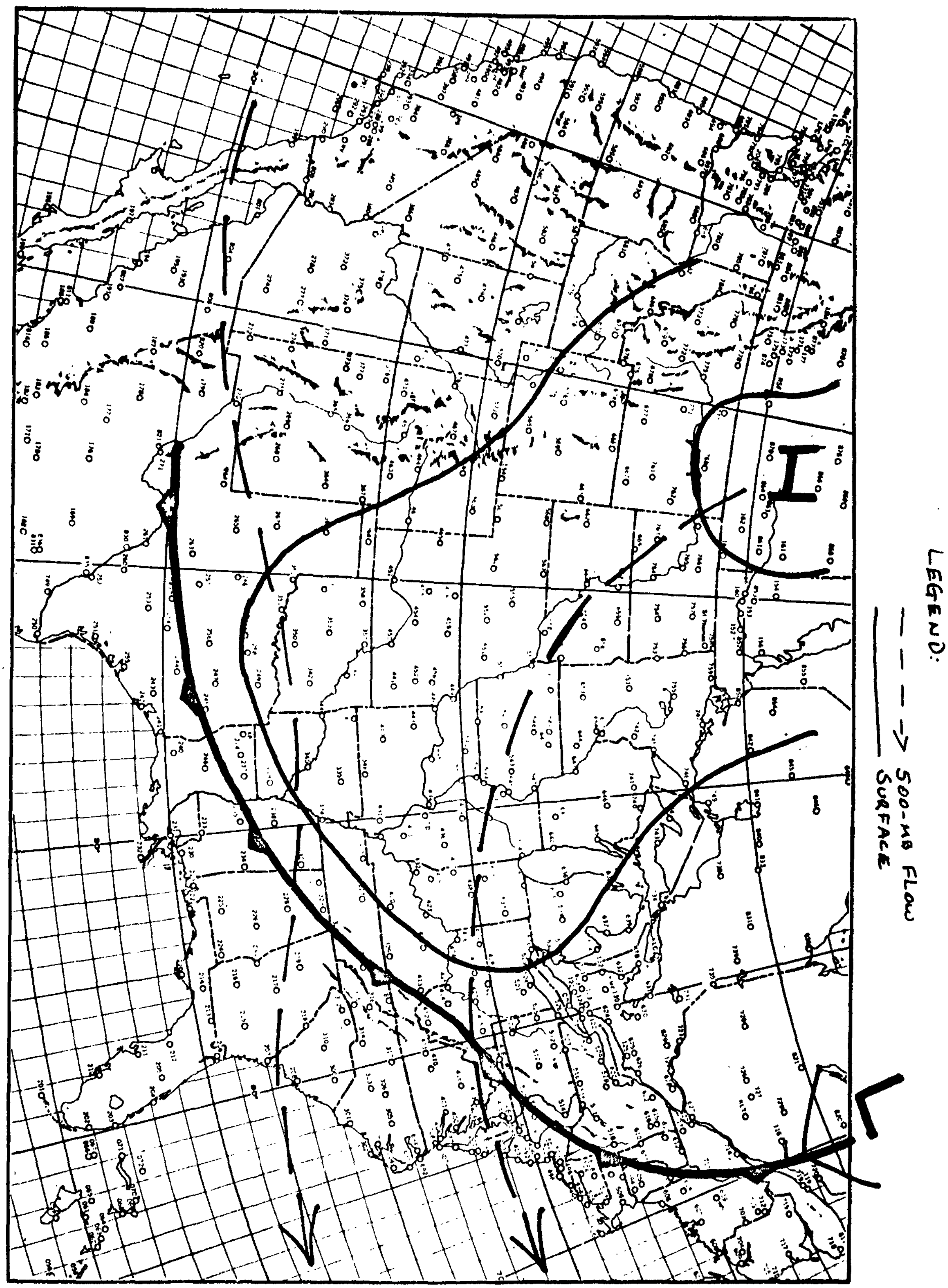
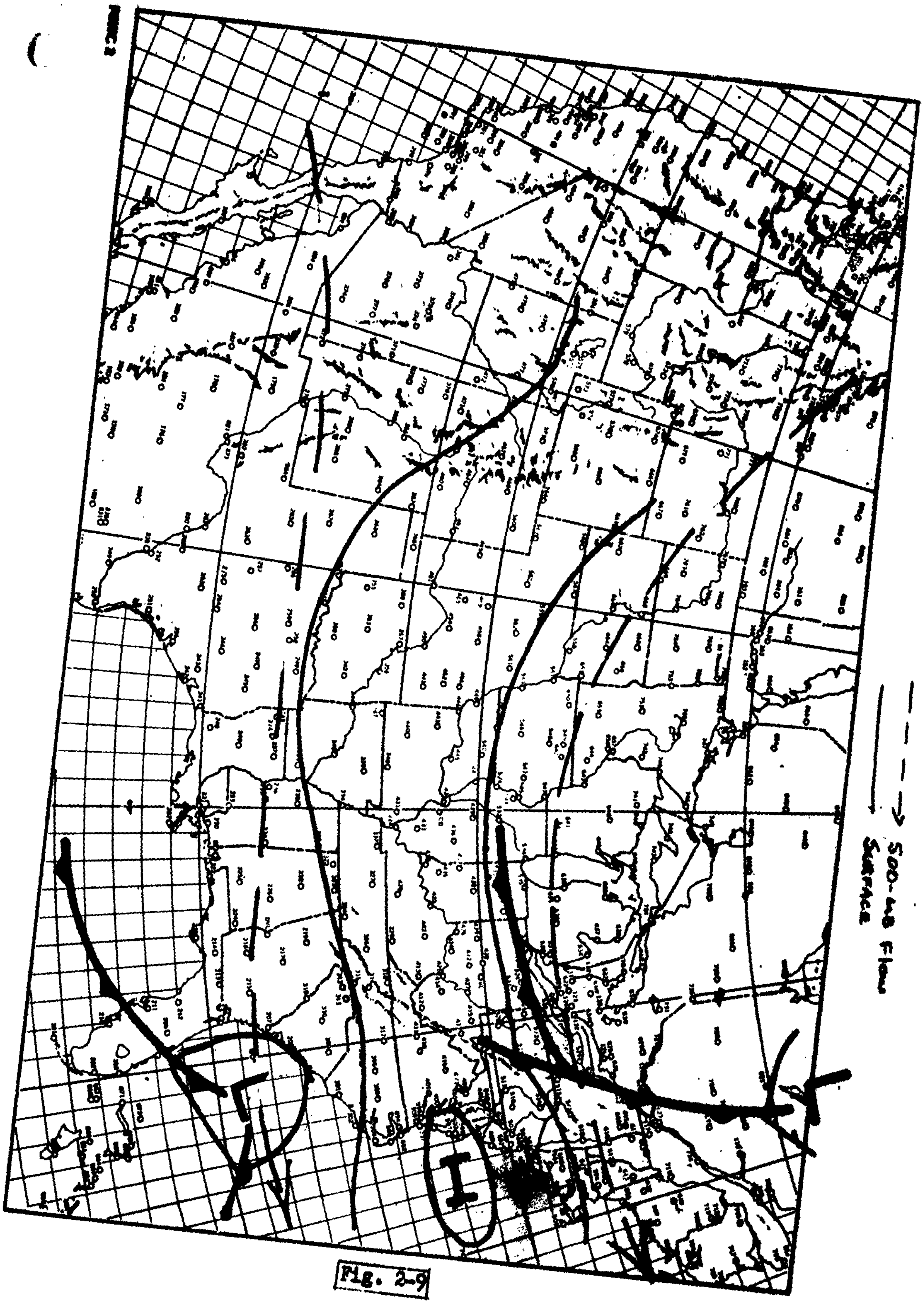


Fig. 2-8

Figure 2-8

WINTER:

The major trough is over or just east of Dover. Lows form northwest of Hudson Bay and generally move around the periphery of the upper closed low. A trailing cold front followed by cP or A air, sweeps southward to the Gulf Coast with the high centers passing to the south of Dover. Waves without major development form on the trailing cold front, and can result in a weak snowfall in the Delaware area. Usually a Sc overcast of 1000-1500 feet and light snow flurries are the only related phenomena at Dover. Snow showers from off the Great Lakes may cross the Appalachians during this regime in the cold outbreaks, however, there instability type snow flurries seldom reach to Dover.



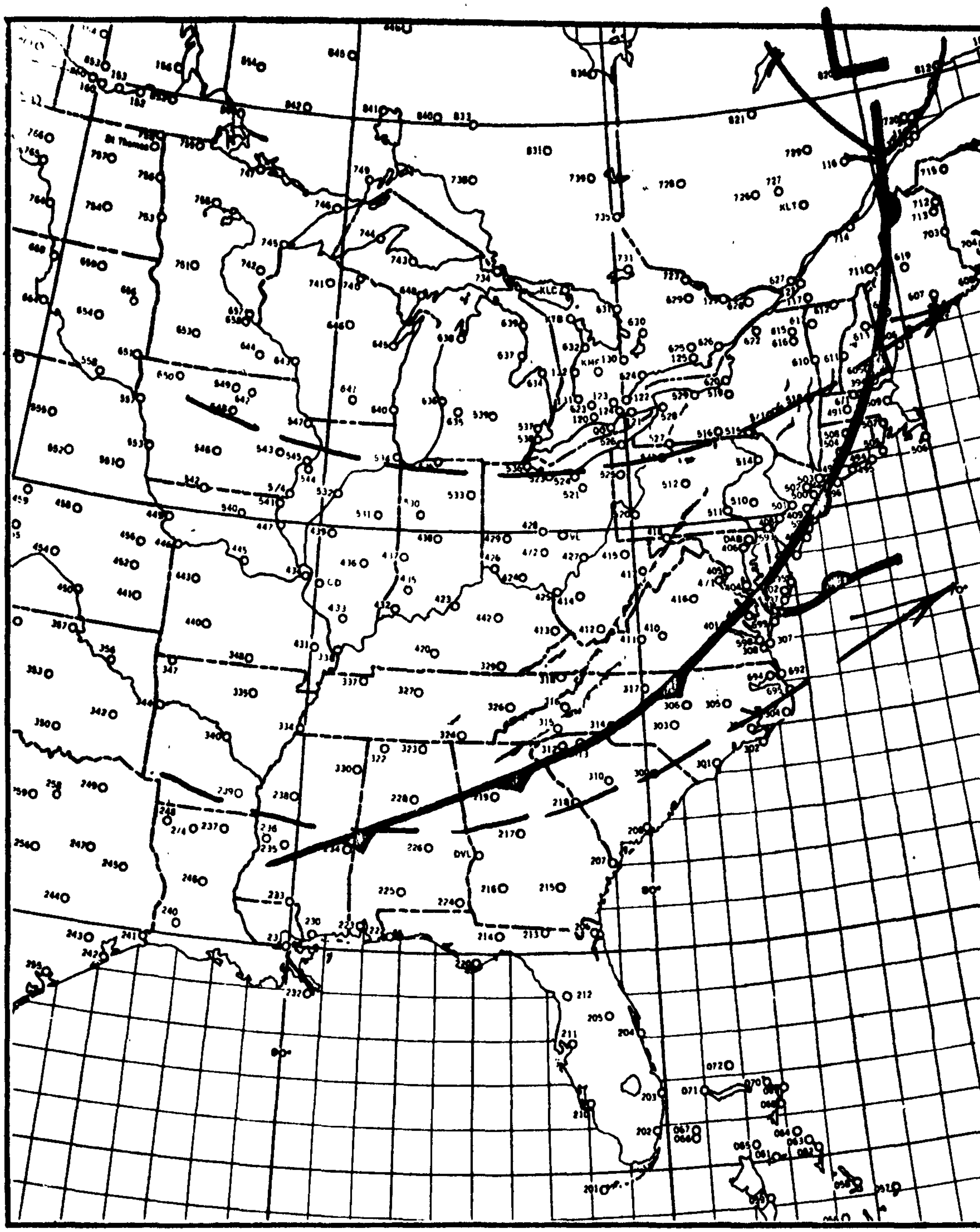
LEGEND:
——→ 500-MB Flow
— — — Surface

Fig. 2-9

Figure 2-9

WINTER:

A split jet results in northern lows, trailing cold fronts which remain in Canada, and southern lows which move eastward across the Gulf Coast states. If the high axis is north of Dover, low clouds, fog, drizzle exist; if the axis is to the south, the weather is characterized by the warm clear days of mP air.



PSWC 6

Fig. 2-10 LEGEND

——— ——— → 500-MB Flow

Figure 2-10

SUMMER:

Weak meridonal flow of the jet stream and a relatively intense Bermuda high will commonly produce frontal thunderstorms along a cold front from a surface low moving just north of the jet. Severity of thunderstorm activity in Dover area will depend on strength of 500 mb jet. Generally speaking, severe thunderstorms occur at Dover when 500 mb flow pattern is WSW to NW and wind velocity is approximately 50 knots or more. A 500 mb maximum isotack of this speed, moving towards Dover, results in an ideal situation for severe thunderstorms. Past experience has indicated that thunderstorms which form over the Delaware Peninsula are more likely to produce severe weather as compared to those which form west of the Chesapeake Bay. It is believed that the thunderstorm weaken in passing across the Bay.

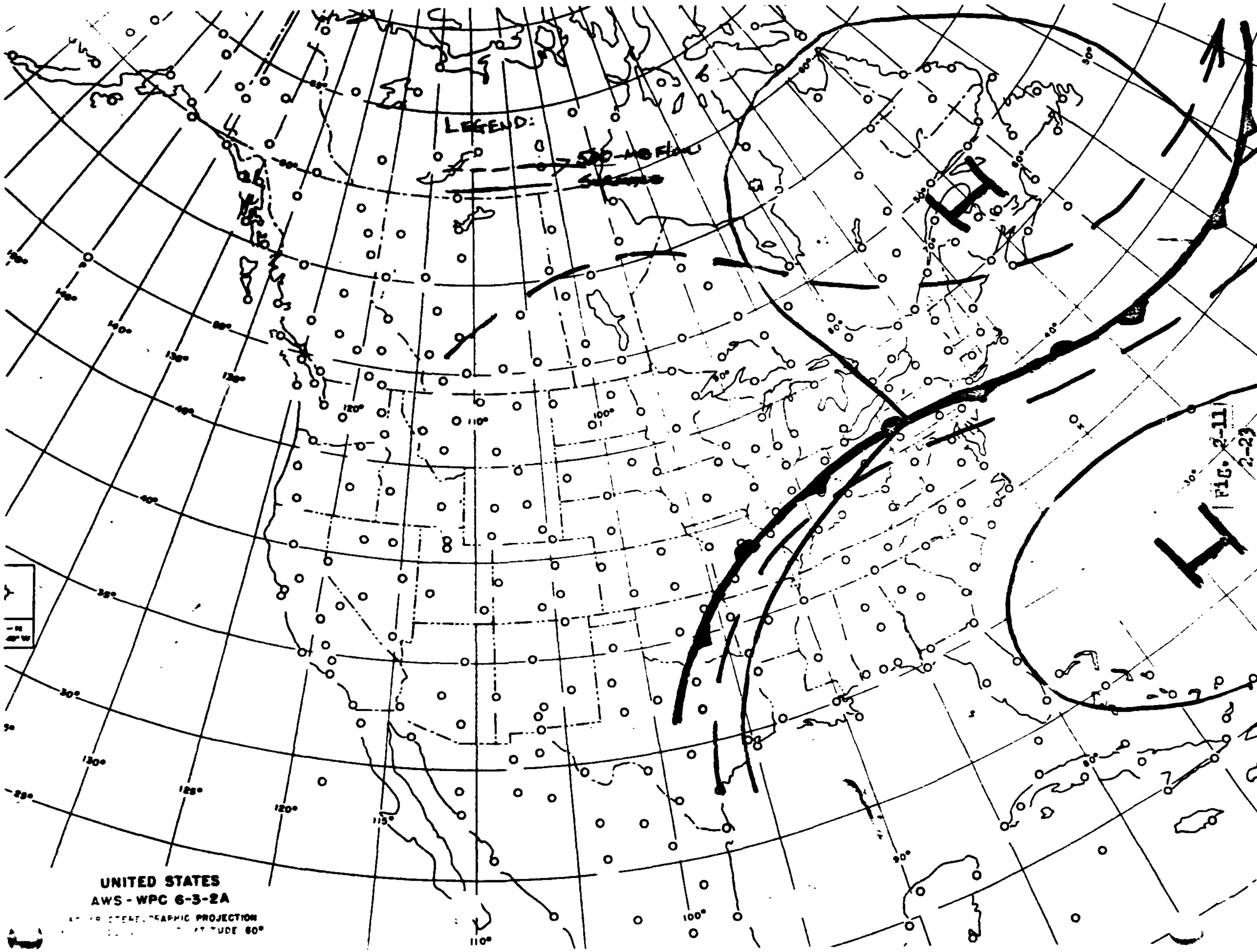
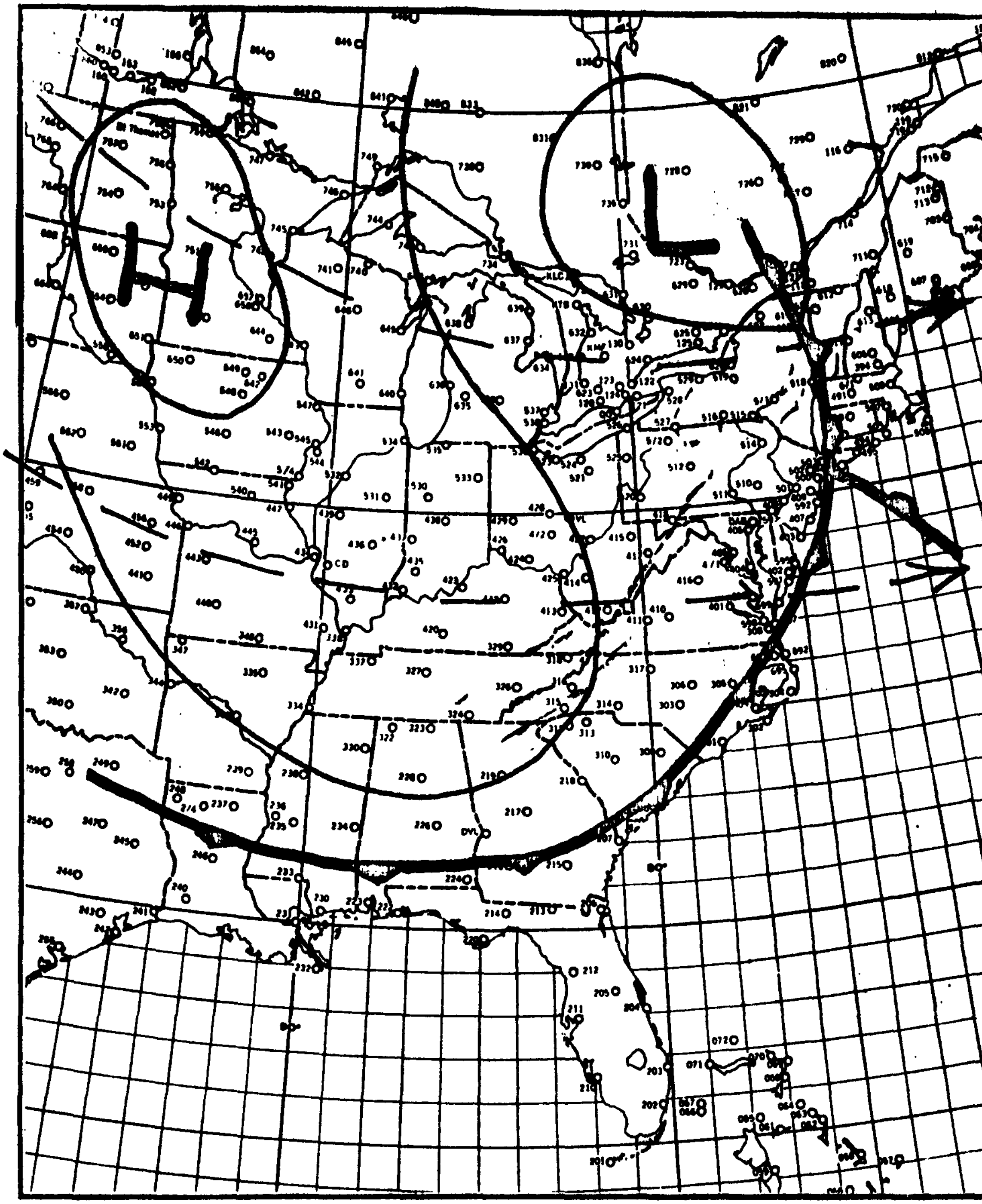


FIG. 2-11

Figure 2-11

SUMMER:

The "backdoor" frontal passage. With a strong Bermuda High extending westward to the Mississippi Valley, persistent high pressure over Northern Quebec and the Icelandic Low displaced well to the south. Lows will form north of Quebec and move SE into the Mid-Atlantic Low with a trailing cold front passing over Dover to become stationary in Virginia or the Carolinas. While the front is south of Dover, we have low stratus and fog (it will go below 200' and 1/2 mile during April or May, or while the front is passing Dover from south to north.) With the front north of Dover, MT air prevails in the area and late afternoon and evening thundershowers are likely to occur.



PSWC 6

Fig.2-12 LEGEND:

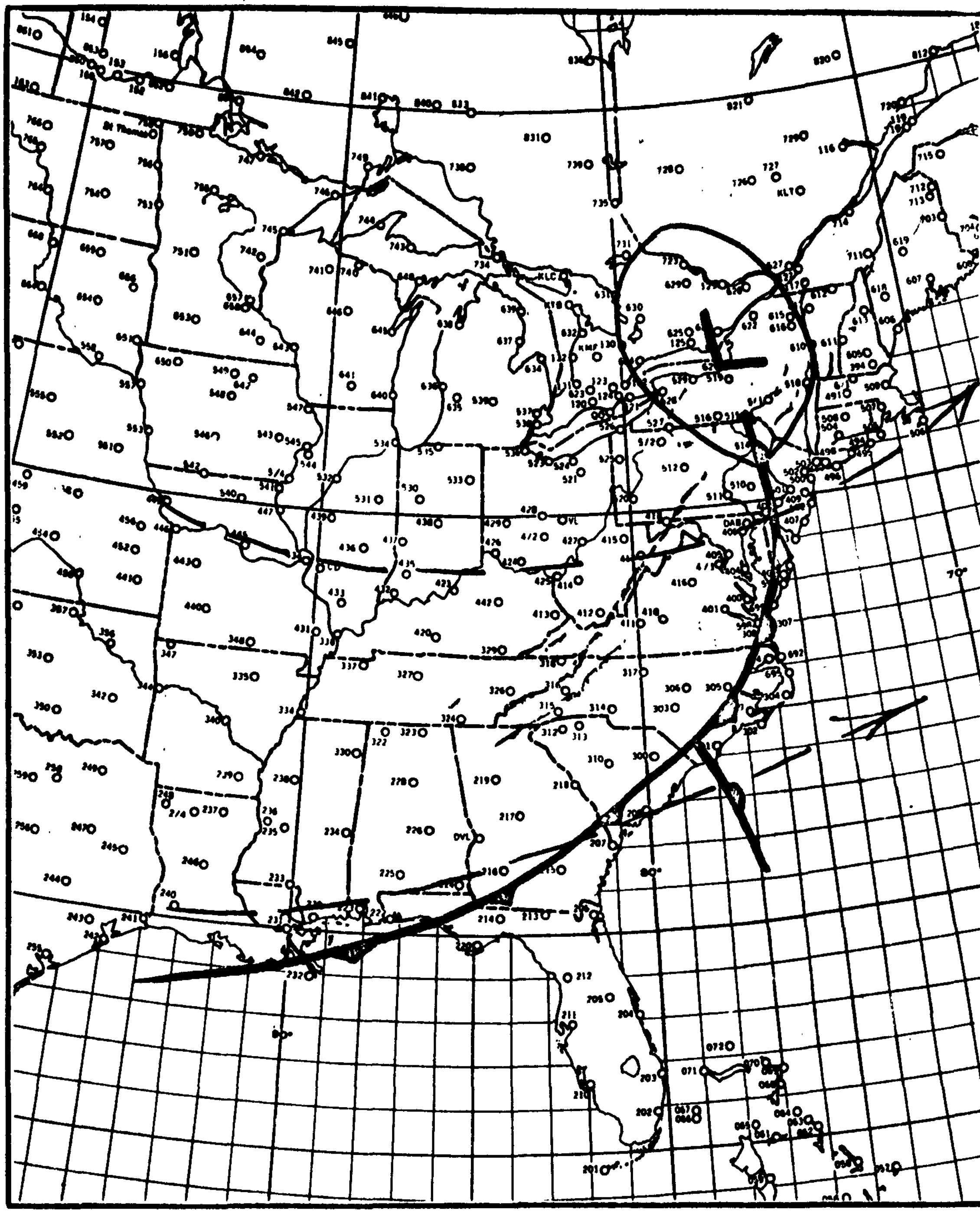
- - - - → 500-MB FLOW

———— SURFACE

Figure 2-12

WINTER:

Waves from a low in the vicinity of British Columbia are fed across the Great Plains then northeastward to Labroador with the trailing cold front moving as far south as Cuba. Extremely cold CP and A air follow the cold fronts accompanied by the winter's coldest weather along the east coast. In the regime, the major trough is near Dover and advances or retrogresses some 15 degrees to parallel the cold fronts as they sweep off the east coast. During this time, the Bermuda High is displaced eastward. The warm frontal weather is the major feature of this type of system. Ceilings will vary from 500-1000 feet with 1-3 miles in rain and fog. Light showers will generally accompany the cold front, although often times no weather is associated with cold front. This is especially true if it is the second or third cold frontal passage of a series. Clear skies and gusty surface winds of 25-35 knots are the rule following cold frontal passage.



PSWC 6

Fig. 2-13

LEGEND

— — — → 500-MB Flow

Figure 2-13

WINTER:

This situation is somewhat similar to Fig.2-13 except major trough over Mississippi Valley is deeper. This is usually the situation accompanying the first major cold outbreak into central U.S. The major low pressure centers track across the Great Lakes. The initial cold front passage at Dover results in rain showers with ceilings 1000-2000 feet and visibilities 1-3 miles. The weather is brief and confined to the immediate frontal zone.

This type situation is ideal for formation of Gulf lows on the trailing cold front. These waves deepen rapidly as they move northward along the eastern seaboard producing widespread low ceiling, poor visibilities, and strong surface winds. Conditions at Dover remain above GCA minimums, but gusty surface winds of the order of 30-40 knots are not uncommon. This is not an ideal situation for snowfall at Dover depending on temperatures and depth of cold air over Dover. As a rule, if surface winds are from the ENE through south, rain will occur. If surface winds are north to north-easterly, snow is likely. The rain vs snow forecast study in Section IV will assist the forecaster in determining if precipitation will be rain or snow.

In some cases, the Gulf wave may develop into the main storm center thus setting the stage for the initial invasion of Artic air into the Eastern U.S. This development generally culminates in a low index situation over U.S. and fair, but windy and very cold temperatures are likely to persist for several days.

SECTION III. CLIMATIC AIDS

SECTION III

CLIMATIC AIDS

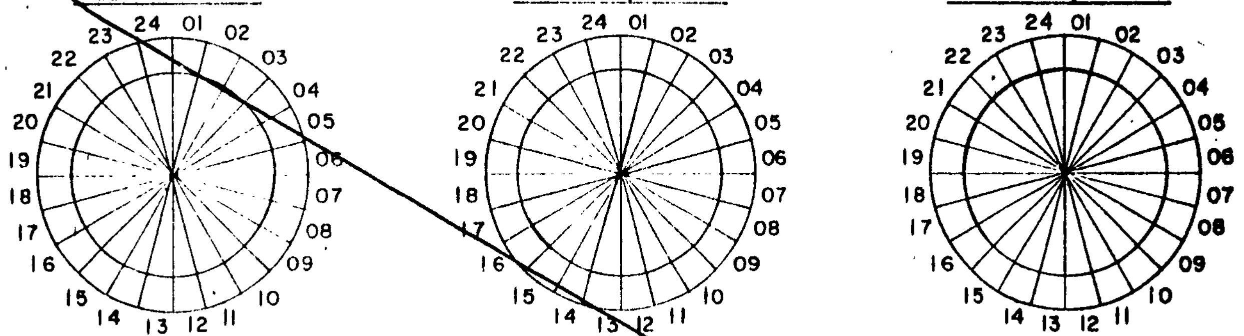
The following Diagrams and Graphs were made from data gathered over a ten-year period and include information for the following: (both monthly and annually)

1. Temperatures
2. Precipitation
3. Sky Cover
4. Ceilings
5. Thunderstorms
6. Visibilities
7. Fog
8. Surface Winds
9. Hurricanes
10. Summary

DOVER AFB CLIMATIC DATA FOR ALL MONTHS

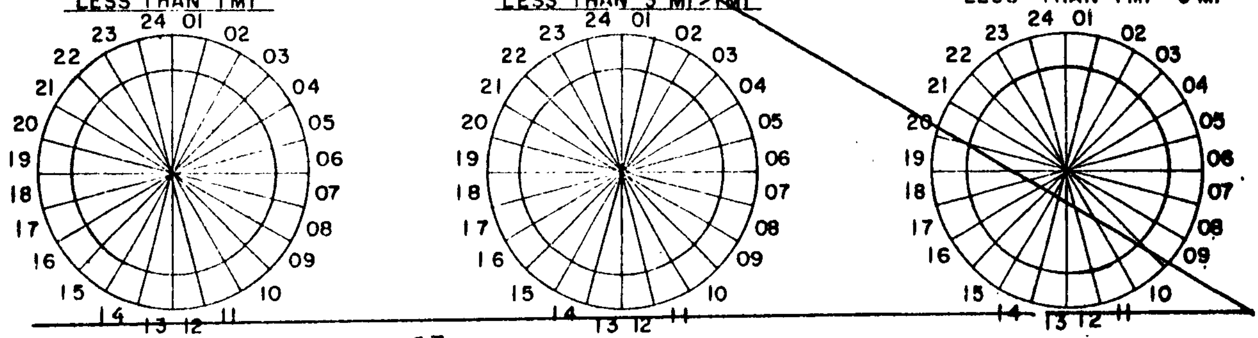
CEILINGS

~~BELOW 500 FT~~ | ~~BELOW 1,000 FT~~ | ~~BELOW 10,000 FT~~

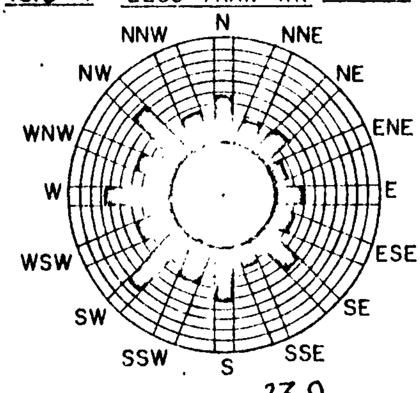


VISIBILITIES

LESS THAN 1MI | LESS THAN 3 MI >1MI | LESS THAN 7MI >3 MI



CALM (8.8%) LESS THAN 11K (65.3%)



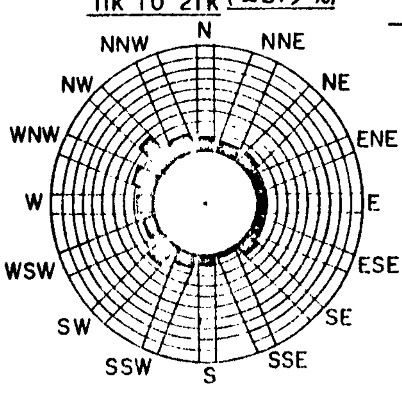
LEGEND:

FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

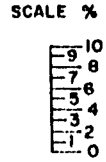
TIMES ARE LOCAL STANDARD.

SURFACE WINDS

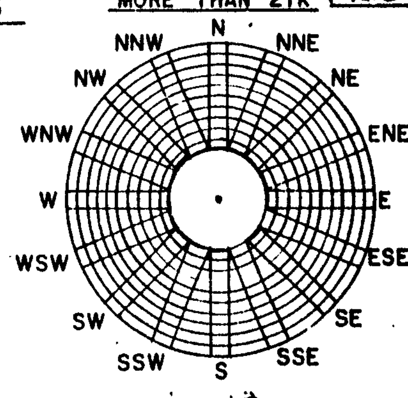
11K TO 21K (23.9%)



SCALE %

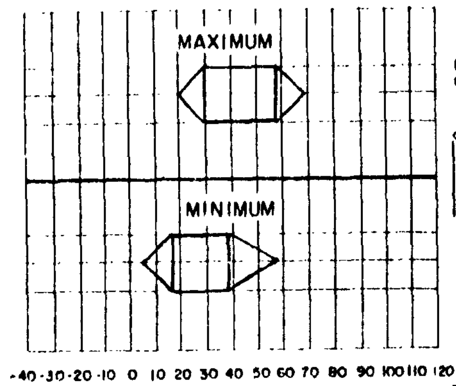


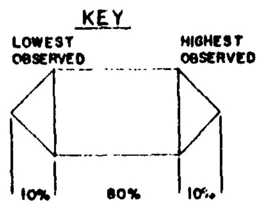
MORE THAN 21K (2.0 %)



DOVER AFB CLIMATIC DATA FOR JANUARY

DAILY TEMPERATURES

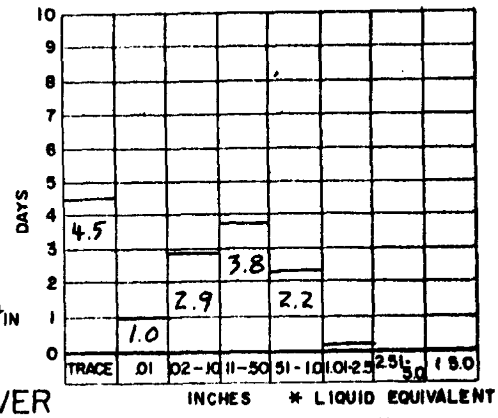




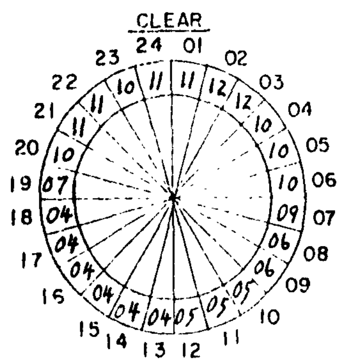
AVG PRECIPITATION 2.94 IN

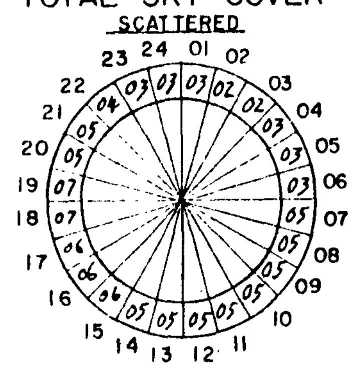
AVG SNOWFALL 4.5 IN

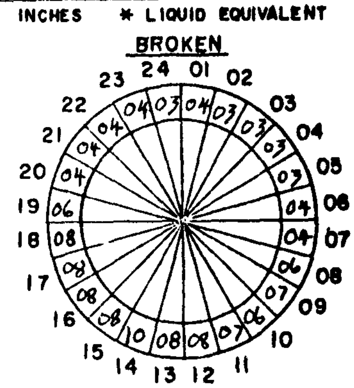
AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS

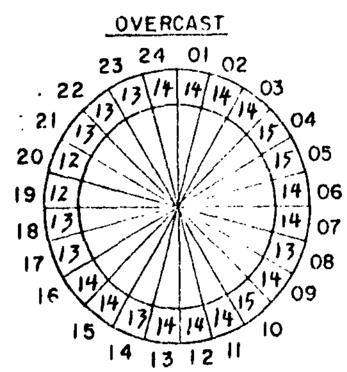


TOTAL SKY COVER







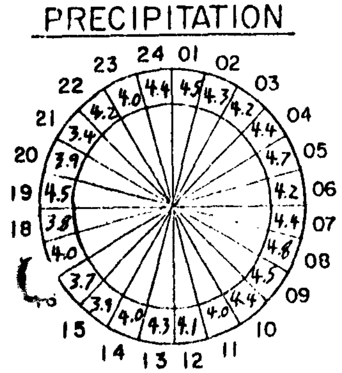


LEGEND

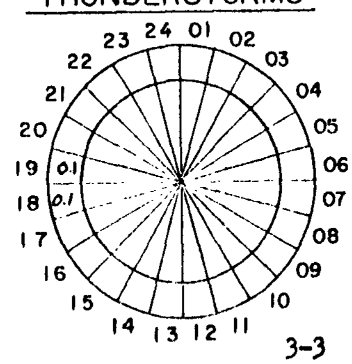
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

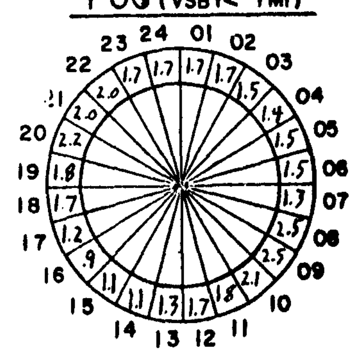
PRECIPITATION



THUNDERSTORMS



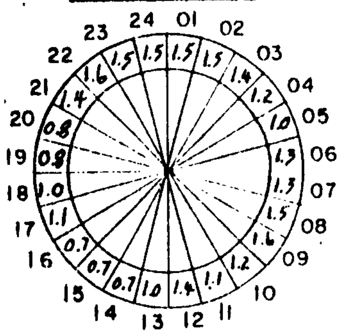
FOG (VSBY< 1MI)



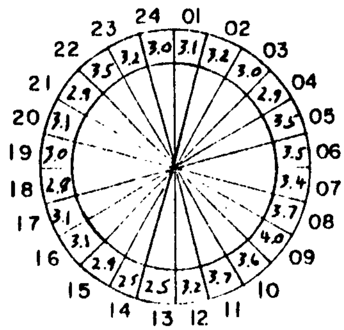
DOVER AFB CLIMATIC DATA FOR JANUARY

CEILINGS

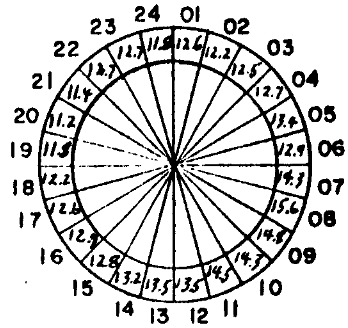
BELOW 500 FT



BELOW 1,000 FT

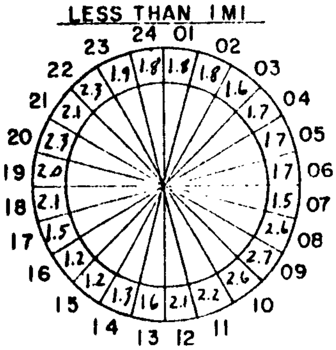


BELOW 10,000 FT

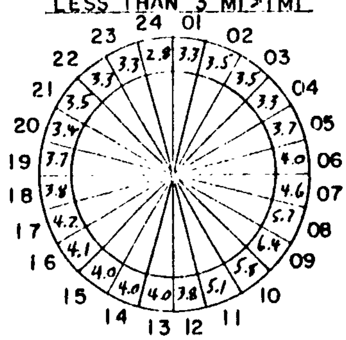


VISIBILITIES

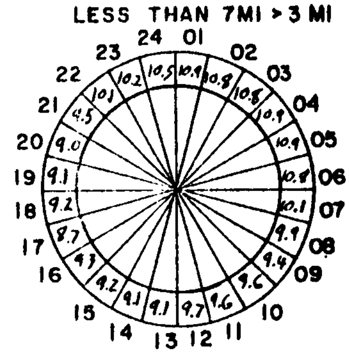
LESS THAN 1 MI



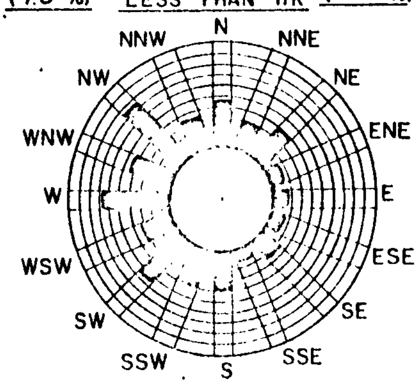
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM (7.0 %) LESS THAN 11K (59.7 %)



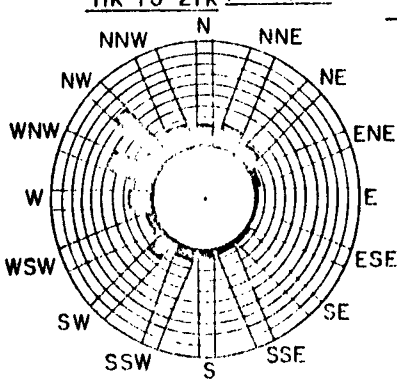
LEGEND:

FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

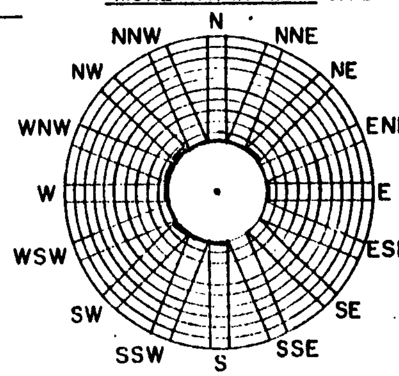
SURFACE WINDS

11K TO 21K (29.9 %)



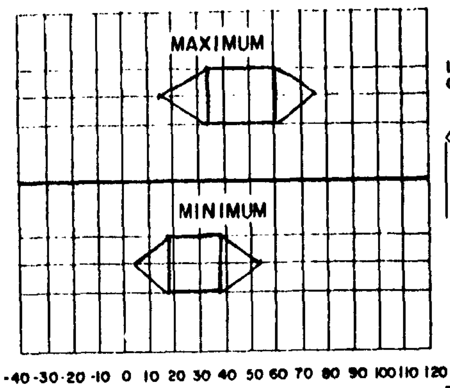
SCALE %

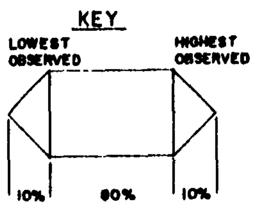
MORE THAN 21K (3.3 %)



DOVER AFB CLIMATIC DATA FOR FEBRUARY

DAILY TEMPERATURES

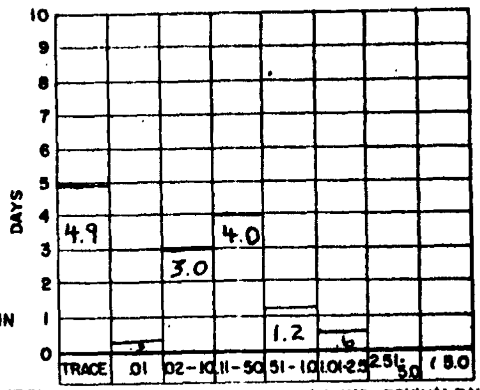




AVG PRECIPITATION 2.48 IN

AVG SNOWFALL 1.9 IN

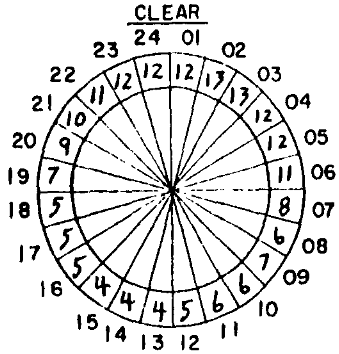
AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS



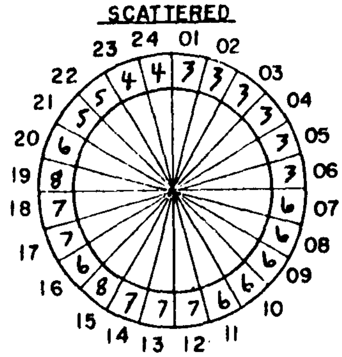
* LIQUID EQUIVALENT

TOTAL SKY COVER

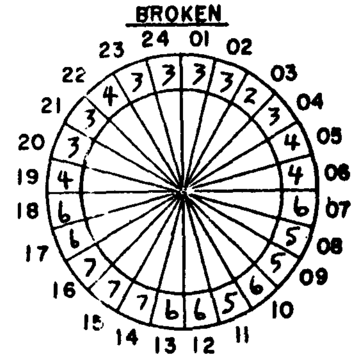
CLEAR



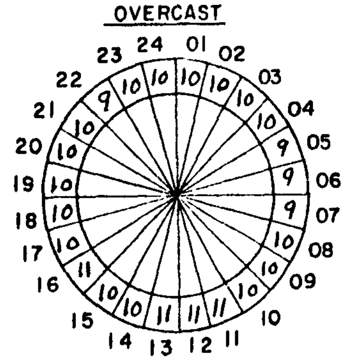
SCATTERED



BROKEN



OVERCAST

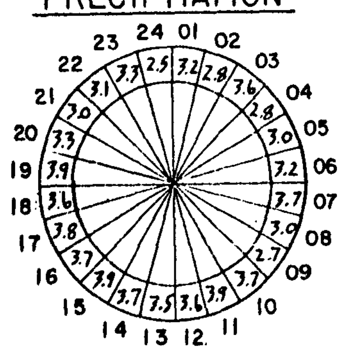


LEGEND

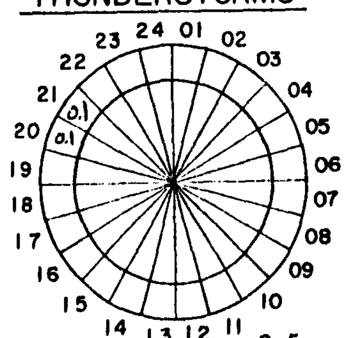
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

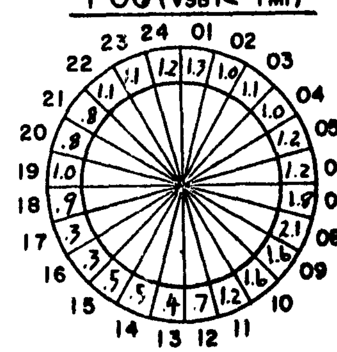
PRECIPITATION



THUNDERSTORMS



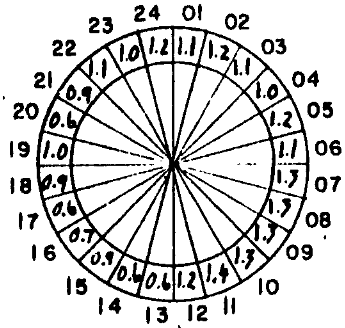
FOG (VSBY< 1MI)



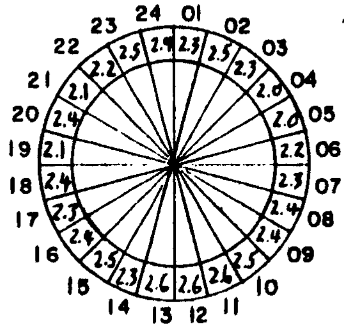
DOVER AFB CLIMATIC DATA FOR FEBRUARY

CEILINGS

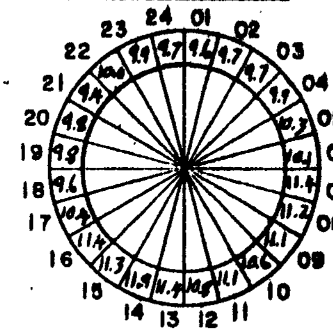
BELOW 500 FT



BELOW 1,000 FT

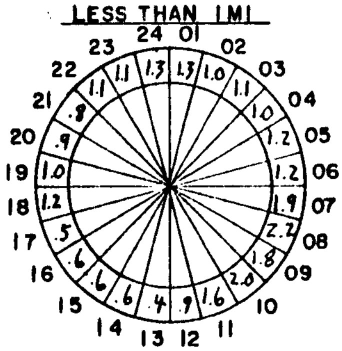


BELOW 10,000 FT

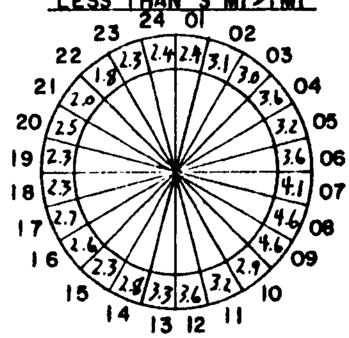


VISIBILITIES

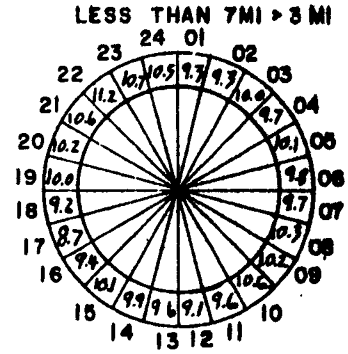
LESS THAN 1 MI



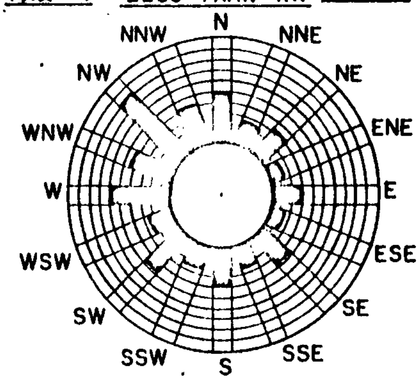
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM (7.2 %) LESS THAN 11K (59.4%)



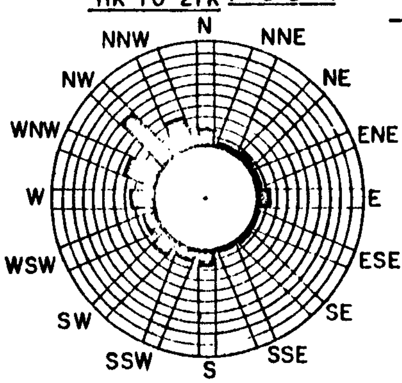
LEGEND:

FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

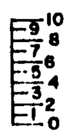
TIMES ARE LOCAL STANDARD.

SURFACE WINDS

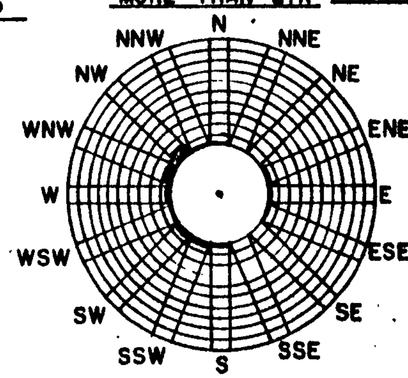
11K TO 21K (28.8 %)



SCALE %

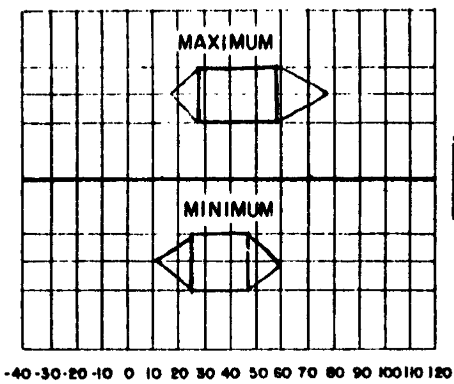


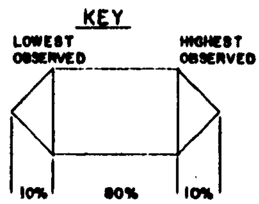
MORE THAN 21K (4.7 %)



DOVER AFB CLIMATIC DATA FOR MARCH

DAILY TEMPERATURES

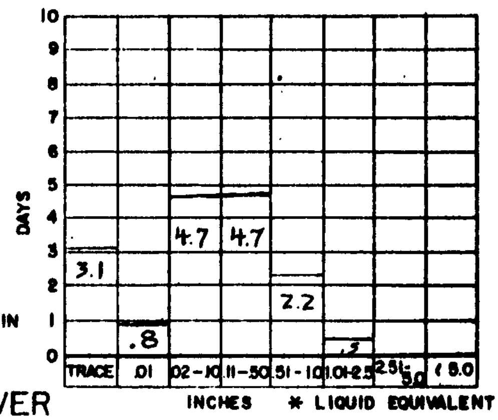




AVG PRECIPITATION 3.77 IN

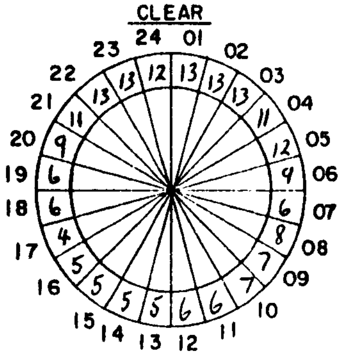
AVG SNOWFALL 2.1 IN

AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS

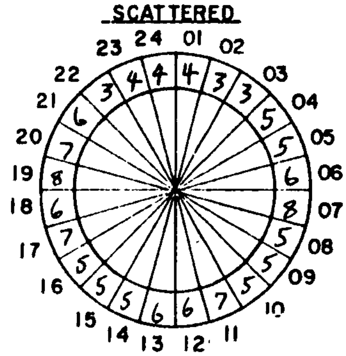


TOTAL SKY COVER

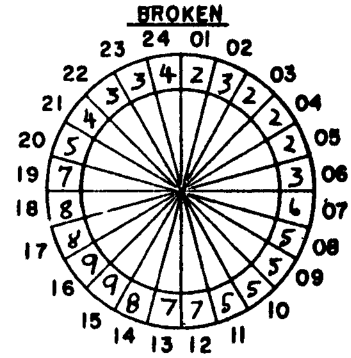
CLEAR



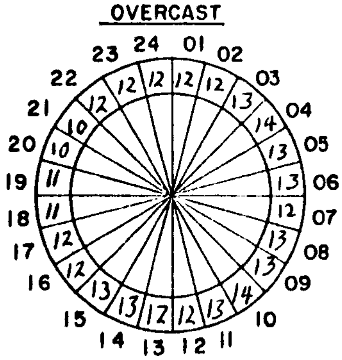
SCATTERED



BROKEN



OVERCAST

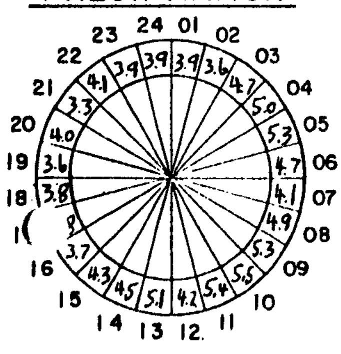


LEGEND

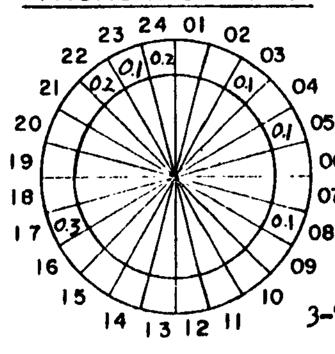
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

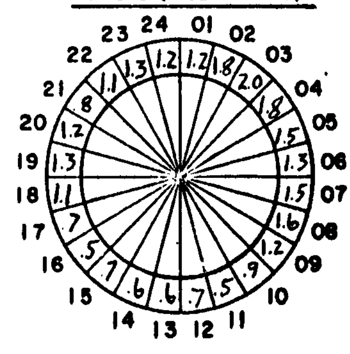
PRECIPITATION



THUNDERSTORMS



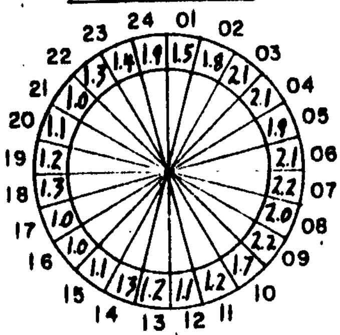
FOG (VSBY< 1MI)



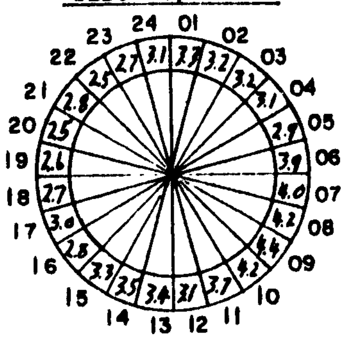
DOVER AFB CLIMATIC DATA FOR *MARCH*

CEILINGS

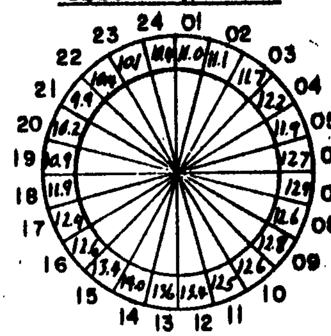
BELOW 500 FT



BELOW 1,000 FT

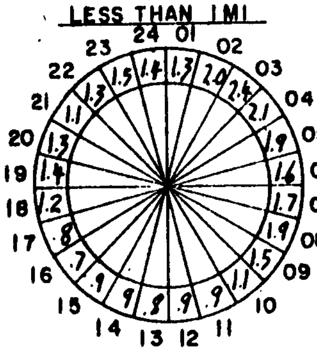


BELOW 10,000 FT

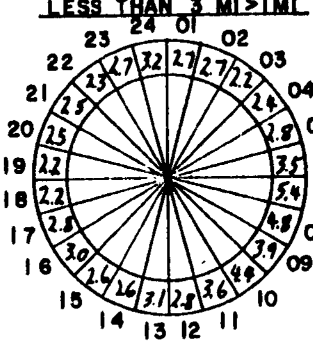


VISIBILITIES

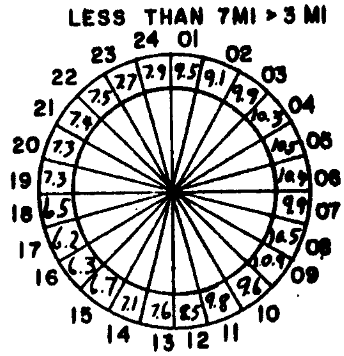
LESS THAN 1 MI



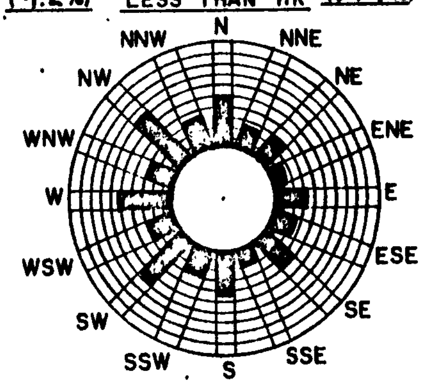
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM *(14.2%)* LESS THAN 11K *(57.4%)*



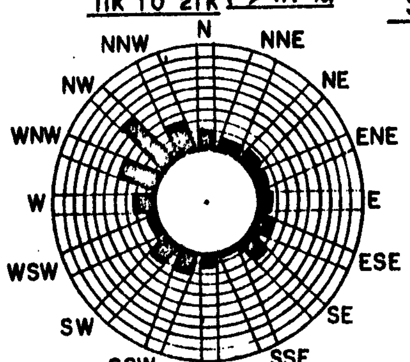
LEGEND:

FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

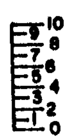
TIMES ARE LOCAL STANDARD.

SURFACE WINDS

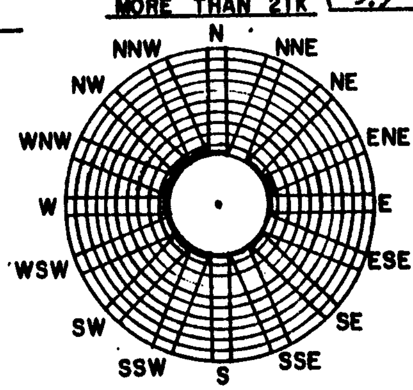
11K TO 21K *(34.7%)*



SCALE %

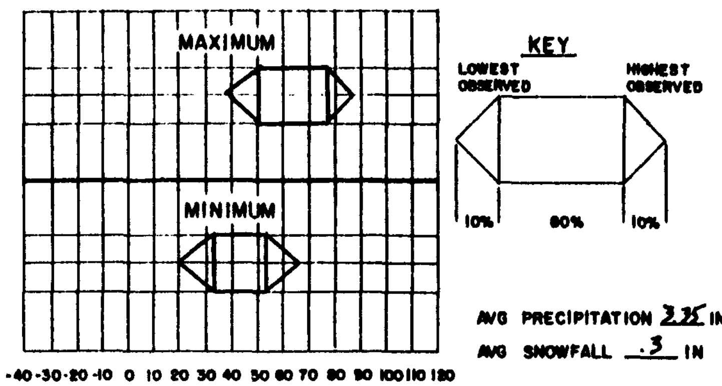


MORE THAN 21K *(3.5 %)*

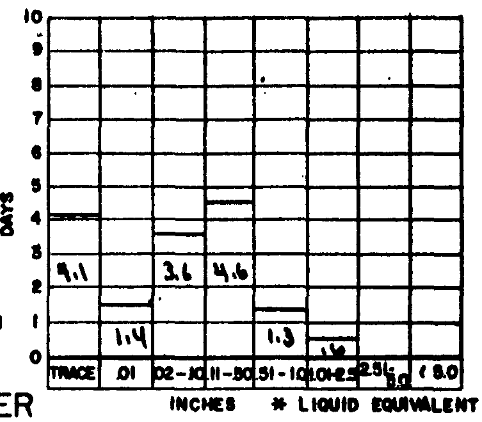


DOVER AFB CLIMATIC DATA FOR APRIL

DAILY TEMPERATURES

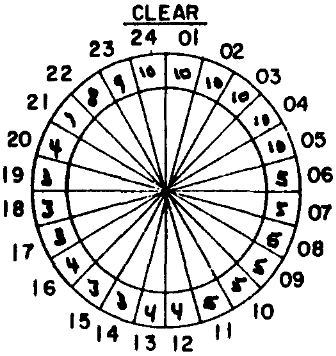


AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS

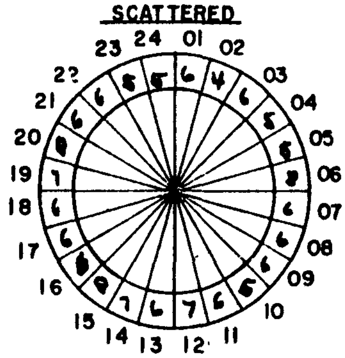


TOTAL SKY COVER

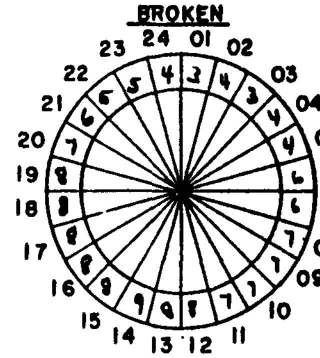
CLEAR



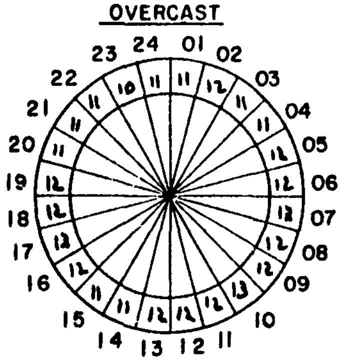
SCATTERED



BROKEN



OVERCAST

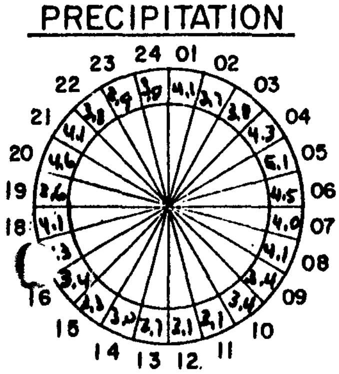


LEGEND

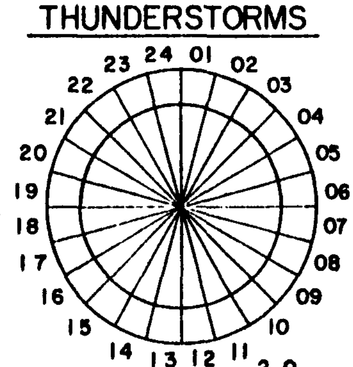
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

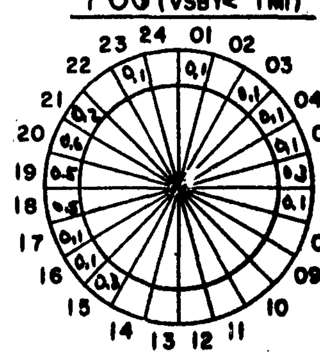
PRECIPITATION



THUNDERSTORMS



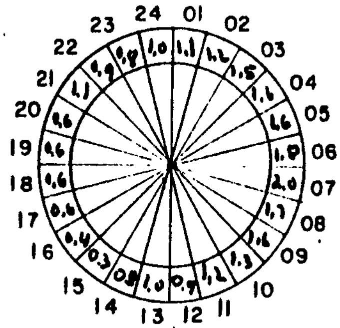
FOG (VSBY< 1MI)



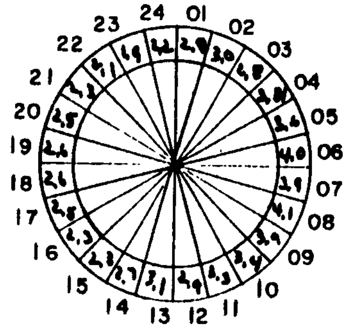
DOVER AFB CLIMATIC DATA FOR APRIL

CEILINGS

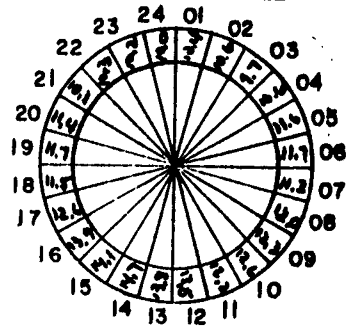
BELOW 500 FT



BELOW 1,000 FT

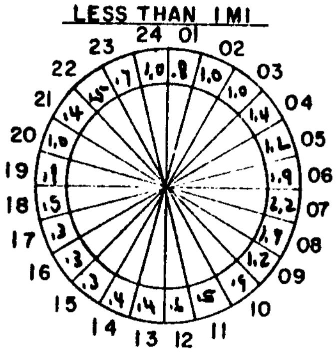


BELOW 10,000 FT

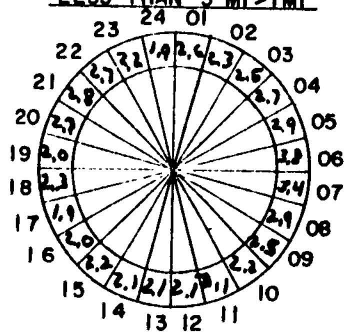


VISIBILITIES

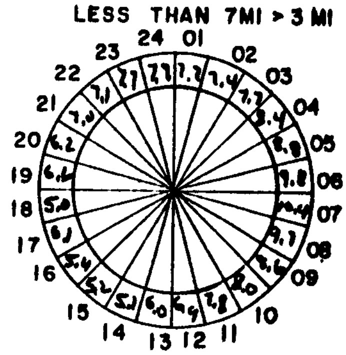
LESS THAN 1 MI



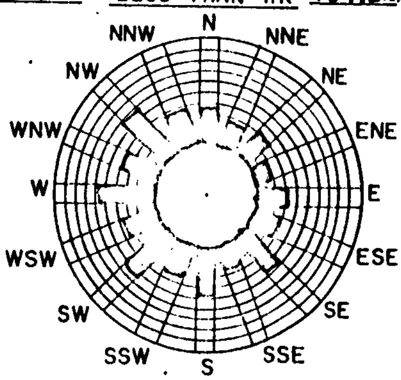
LESS THAN 3 MI >1 MI



LESS THAN 7 MI >3 MI



CALM (5.3%) LESS THAN 11K (59.6%)

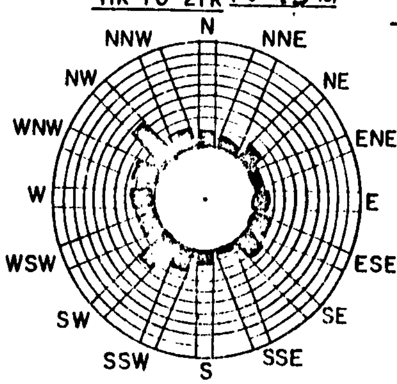


LEGEND:

FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

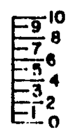
TIMES ARE LOCAL STANDARD.

11K TO 21K (32.3%)

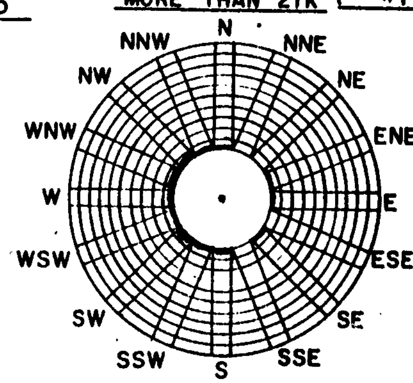


SURFACE WINDS

SCALE %

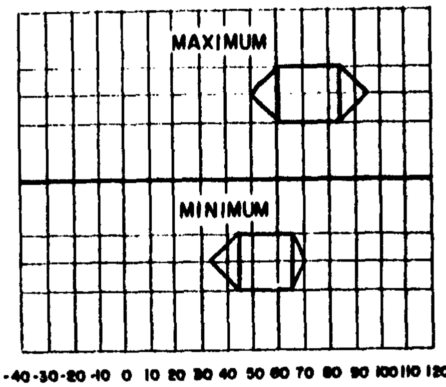


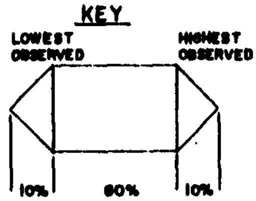
MORE THAN 21K (2.7 %)



DOVER AFB CLIMATIC DATA FOR MAY

DAILY TEMPERATURES

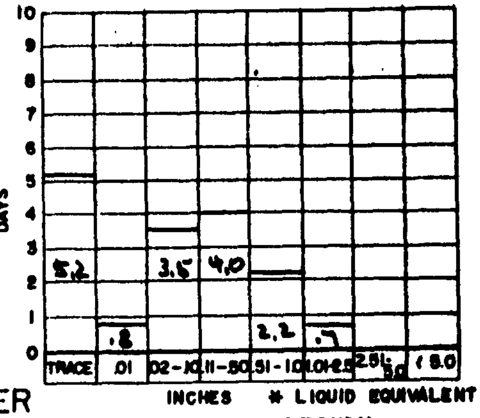




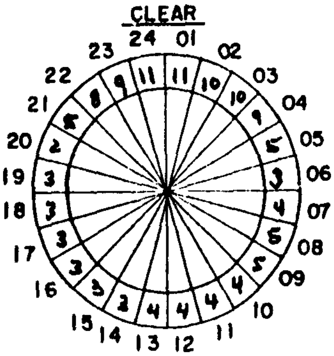
AVG PRECIPITATION 3.95 IN

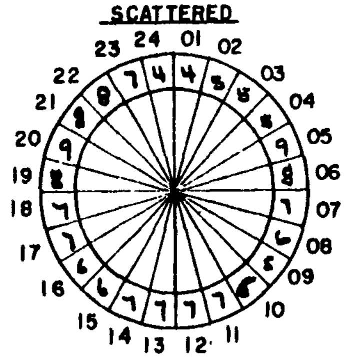
AVG SNOWFALL T IN

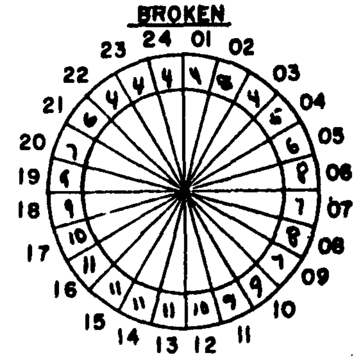
AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS

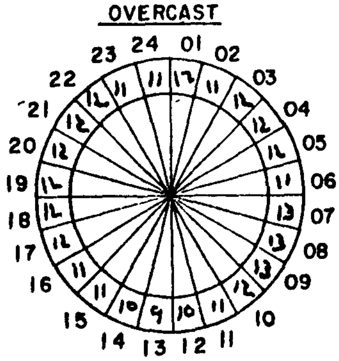


TOTAL SKY COVER







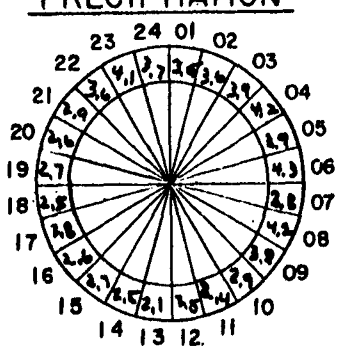


LEGEND

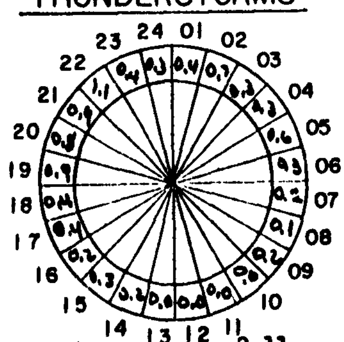
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD

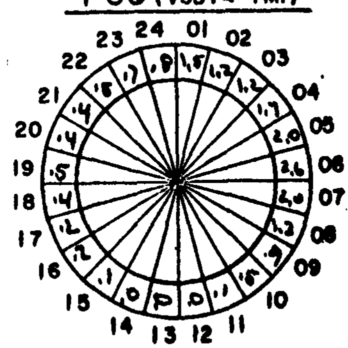
PRECIPITATION



THUNDERSTORMS



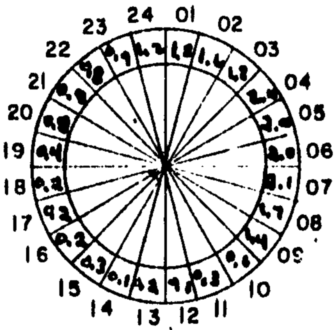
FOG (VSBY< 1MI)



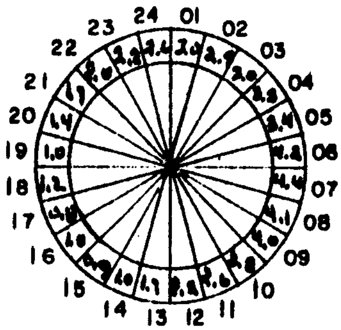
DOVER AFB CLIMATIC DATA FOR MAY

CEILINGS

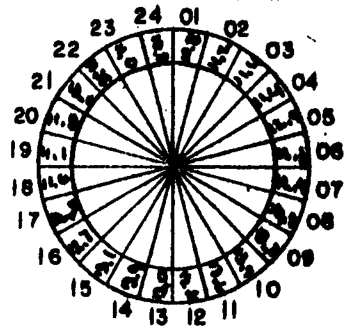
BELOW 500 FT



BELOW 1,000 FT

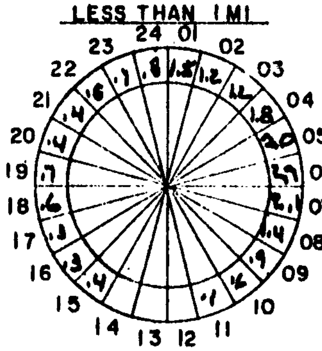


BELOW 10,000 FT

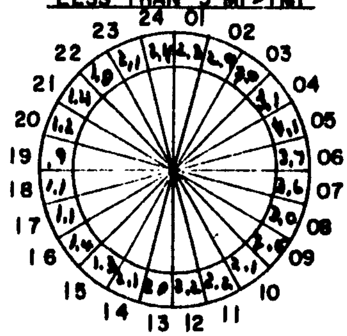


VISIBILITIES

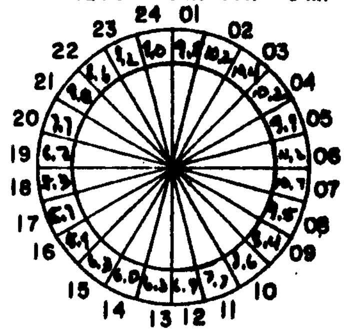
LESS THAN 1 MI



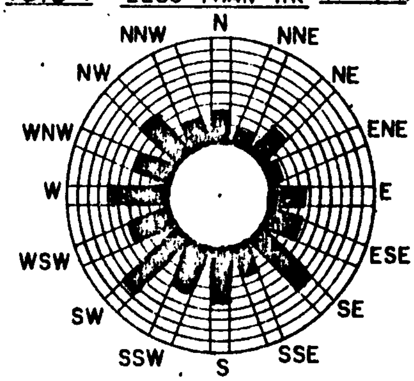
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM (6.6%) LESS THAN 11K (66.7%)



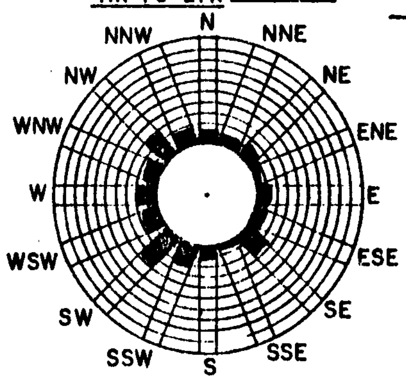
LEGEND:

FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

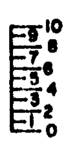
TIMES ARE LOCAL STANDARD.

SURFACE WINDS

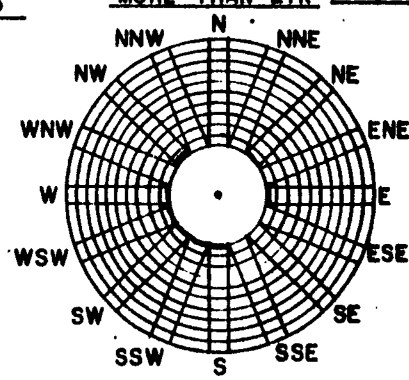
11K TO 21K (25.5 %)



SCALE %

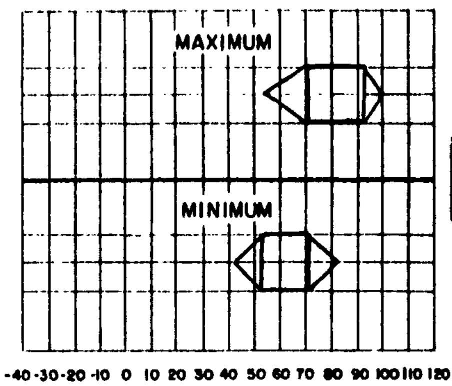


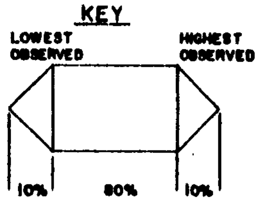
MORE THAN 21K (.1 %)



DOVER AFB CLIMATIC DATA FOR JUNE

DAILY TEMPERATURES

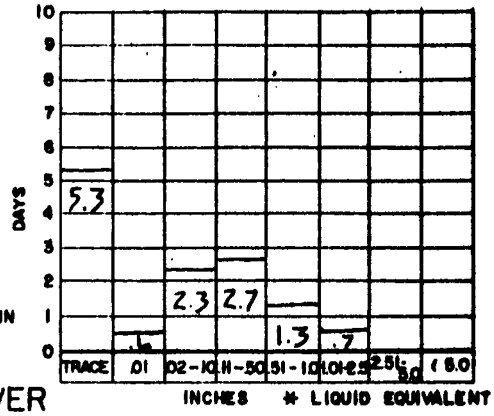




AVG PRECIPITATION 3.11 IN

AVG SNOWFALL T IN

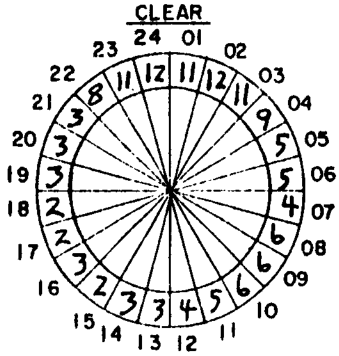
AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS



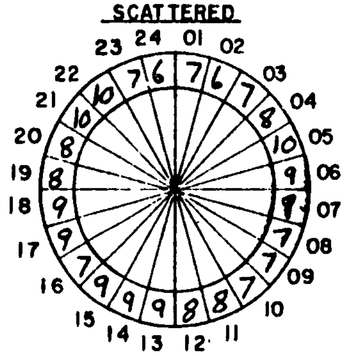
* LIQUID EQUIVALENT

TOTAL SKY COVER

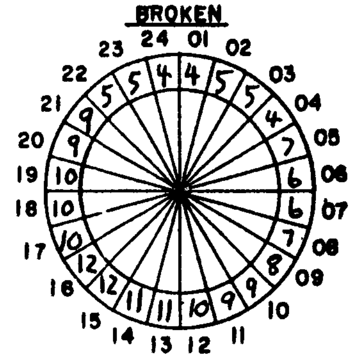
CLEAR



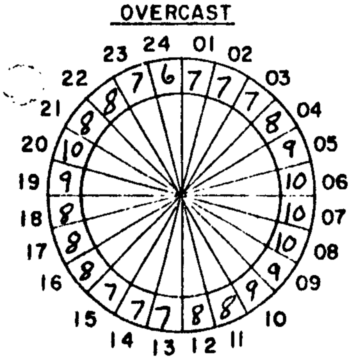
SCATTERED



BROKEN



OVERCAST

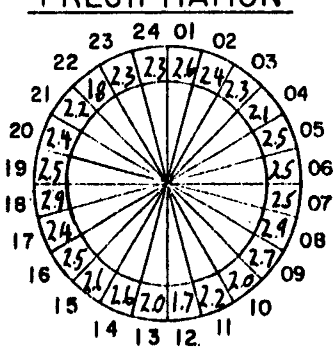


LEGEND

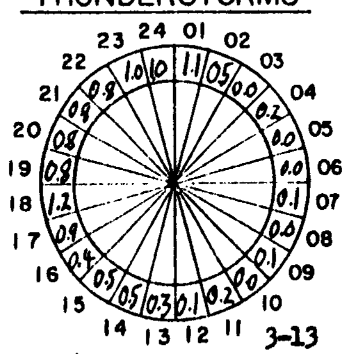
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

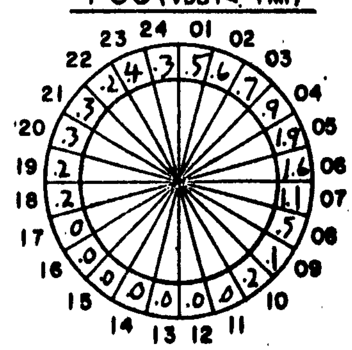
PRECIPITATION



THUNDERSTORMS



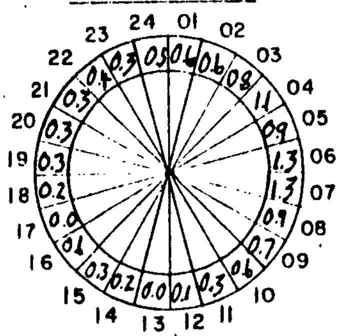
FOG (VSBY< 1MI)



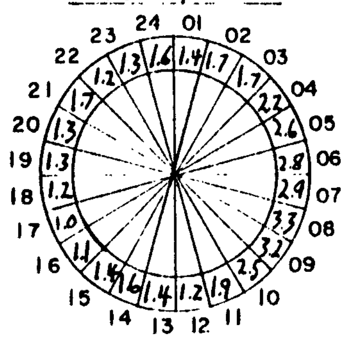
DOVER AFB CLIMATIC DATA FOR JUNE

CEILINGS

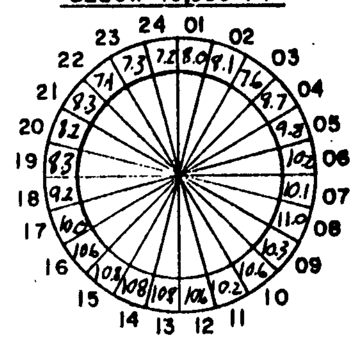
BELOW 500 FT



BELOW 1,000 FT

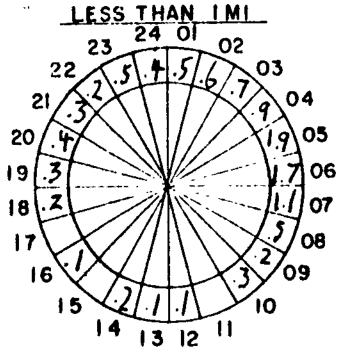


BELOW 10,000 FT

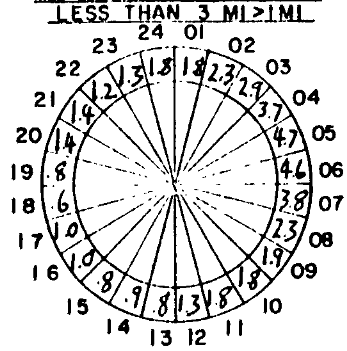


VISIBILITIES

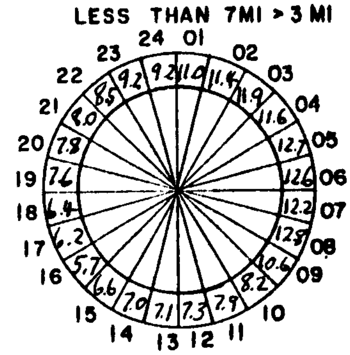
LESS THAN 1 MI



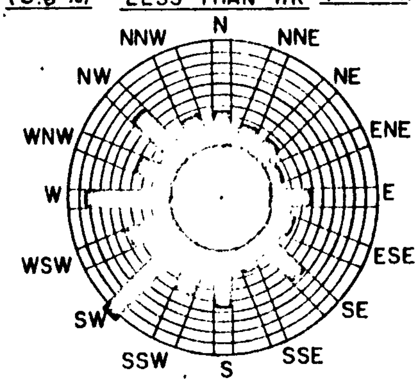
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



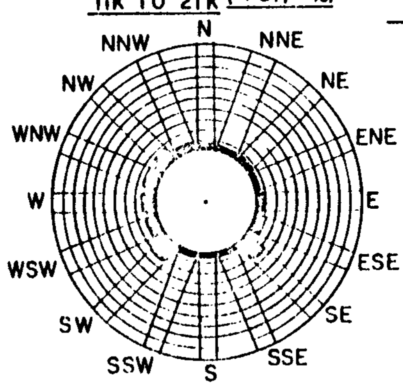
CALM (8.6 %) LESS THAN 11K (72.8 %)



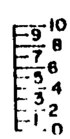
LEGEND:
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.
TIMES ARE LOCAL STANDARD.

SURFACE WINDS

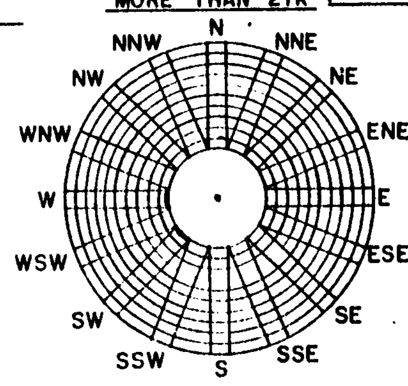
11K TO 21K (18.1 %)



SCALE %

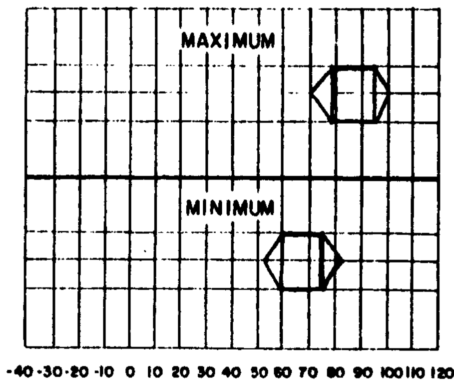


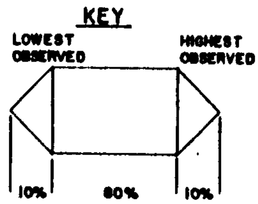
MORE THAN 21K (.5 %)



DOVER AFB CLIMATIC DATA FOR July

DAILY TEMPERATURES

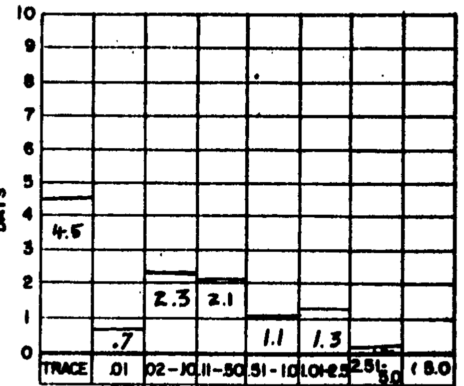




AVG PRECIPITATION 3.93 IN

AVG SNOWFALL .0 IN

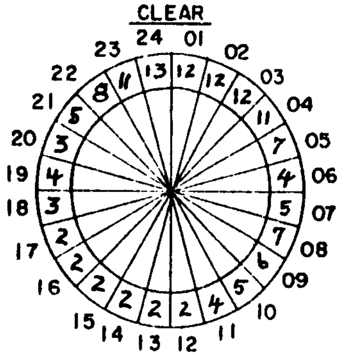
AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS



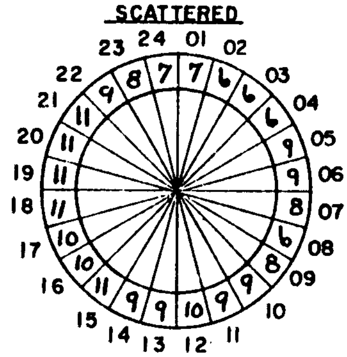
INCHES * LIQUID EQUIVALENT

TOTAL SKY COVER

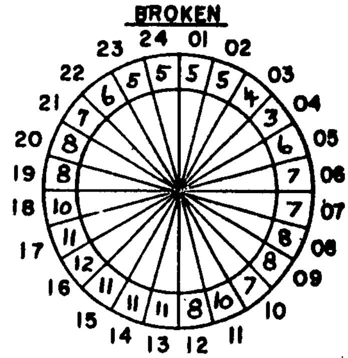
CLEAR



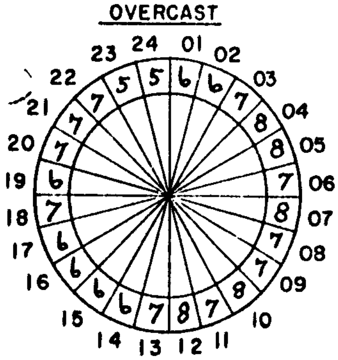
SCATTERED



BROKEN



OVERCAST

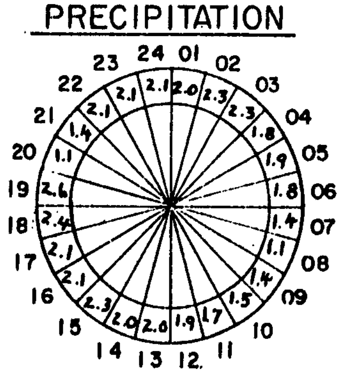


LEGEND

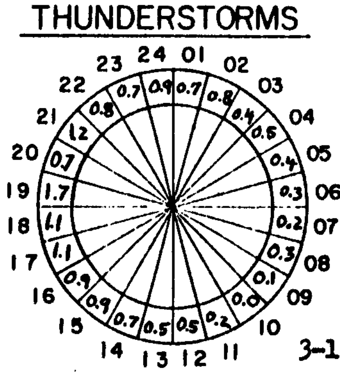
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

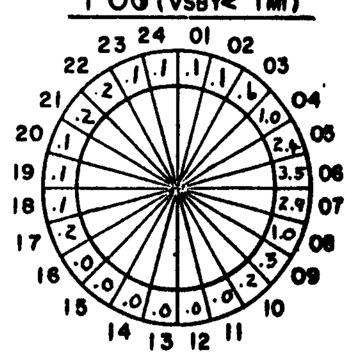
PRECIPITATION



THUNDERSTORMS



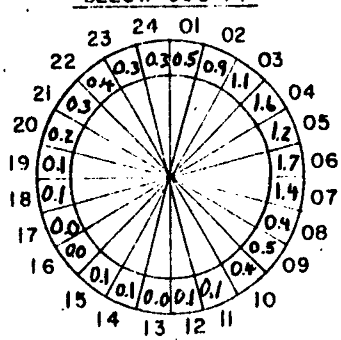
FOG (VSBY< 1MI)



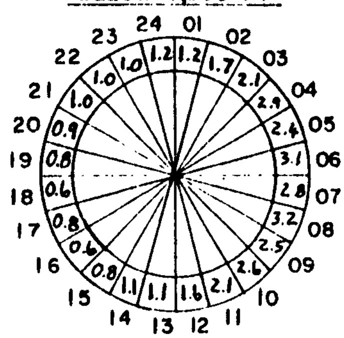
DOVER AFB CLIMATIC DATA FOR July

CEILINGS

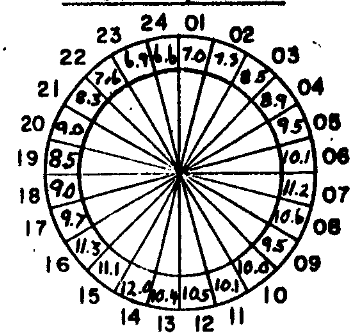
BELOW 500 FT



BELOW 1,000 FT

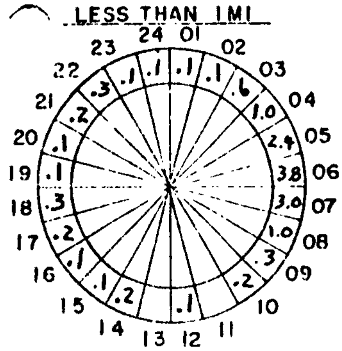


BELOW 10,000 FT

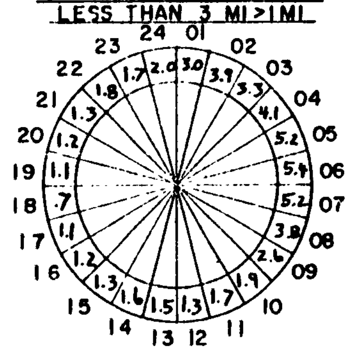


VISIBILITIES

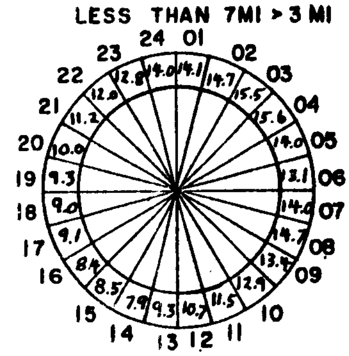
LESS THAN 1 MI



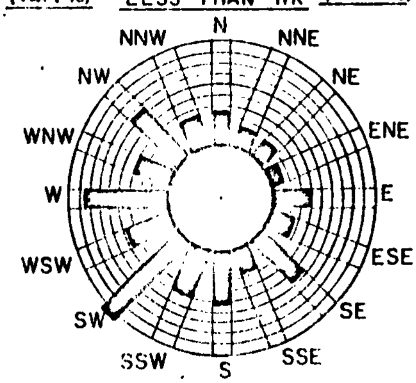
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM (12.4%) LESS THAN 11K (73.6%)

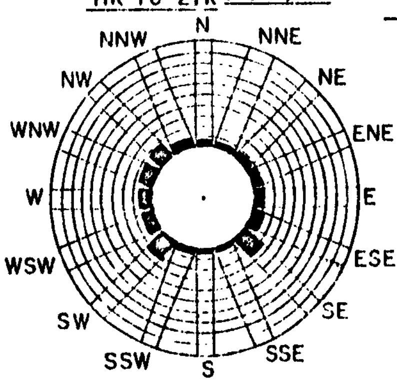


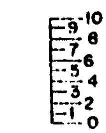
LEGEND:
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.
TIMES ARE LOCAL STANDARD.

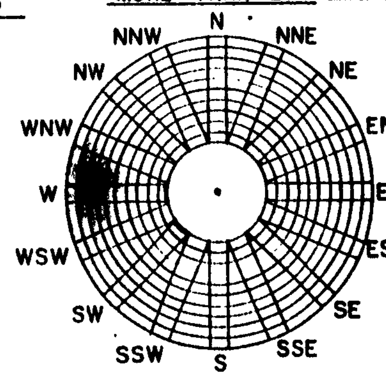
11K TO 21K (13.7 %)

SURFACE WINDS

MORE THAN 21K (.3 %)

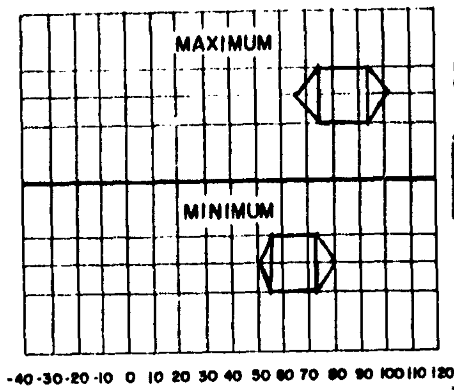




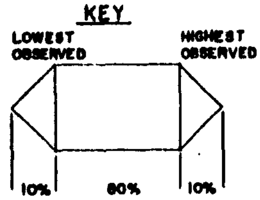


DOVER AFB CLIMATIC DATA FOR AUGUST

DAILY TEMPERATURES



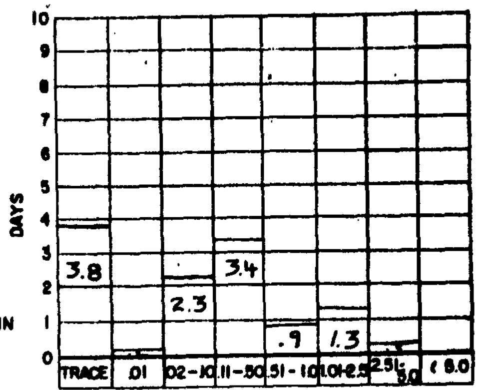
KEY



AVG PRECIPITATION 4.59 IN

AVG SNOWFALL .0 IN

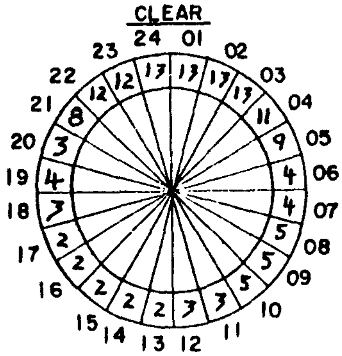
AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS



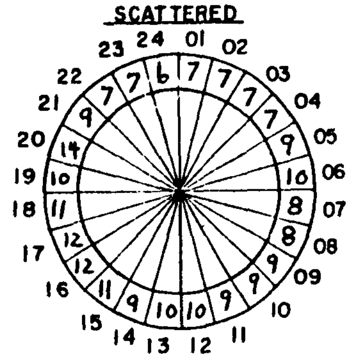
* LIQUID EQUIVALENT

TOTAL SKY COVER

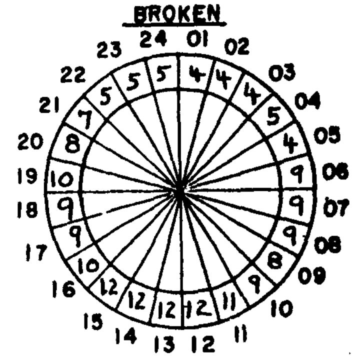
CLEAR



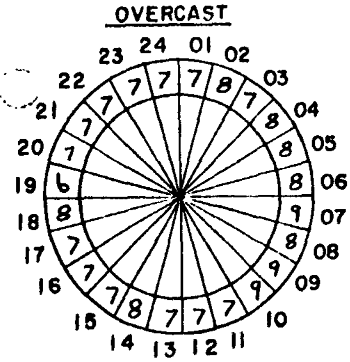
SCATTERED



BROKEN



OVERCAST

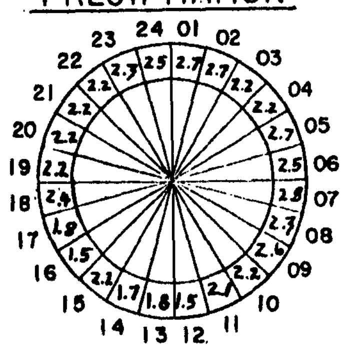


LEGEND

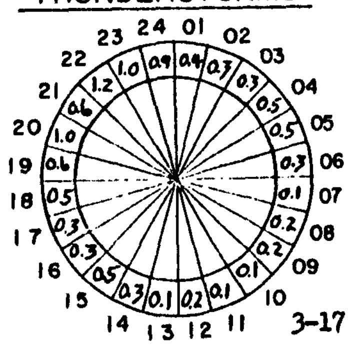
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

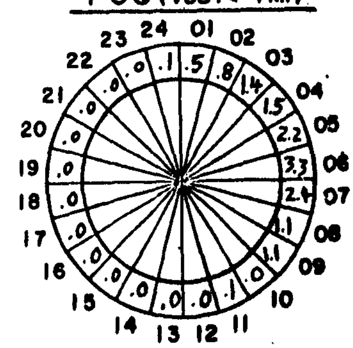
PRECIPITATION



THUNDERSTORMS



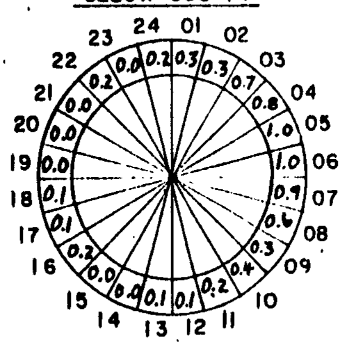
FOG (VSBY< 1 MI)



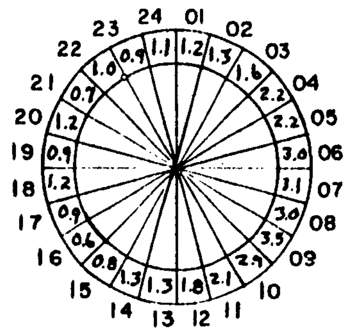
DOVER AFB CLIMATIC DATA FOR AUGUST

CEILINGS

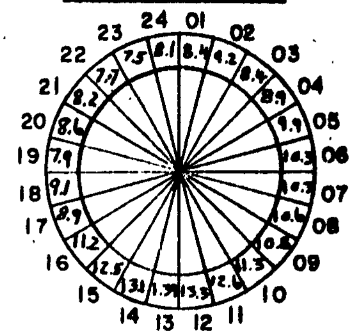
BELOW 500 FT



BELOW 1,000 FT

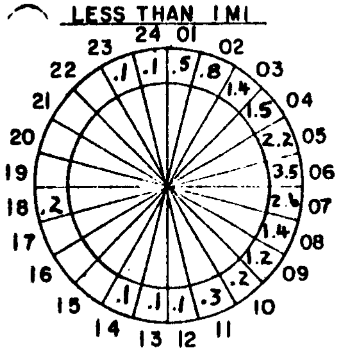


BELOW 10,000 FT

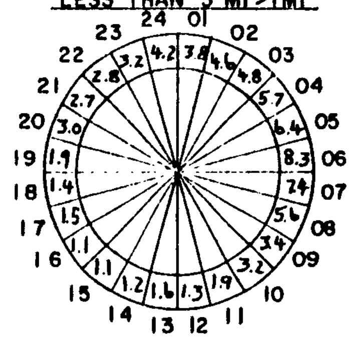


VISIBILITIES

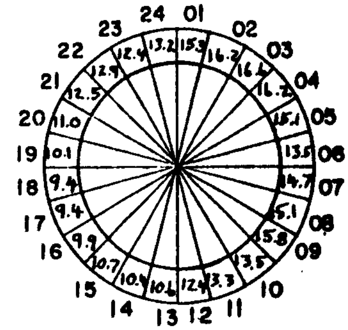
LESS THAN 1 MI



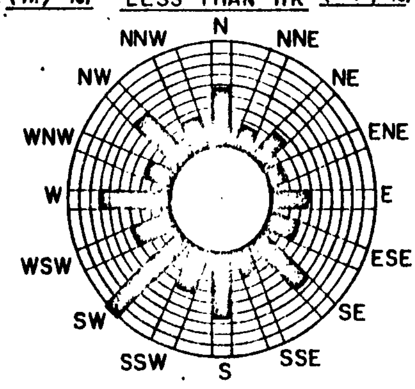
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM (11.7 %) LESS THAN 11K (74.4 %)



LEGEND:

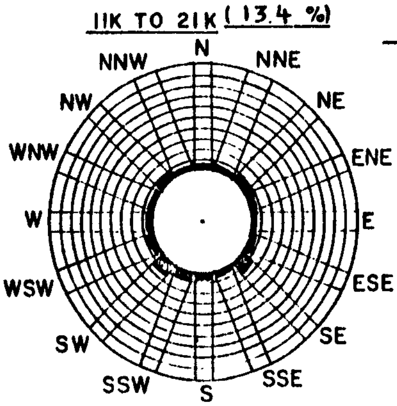
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

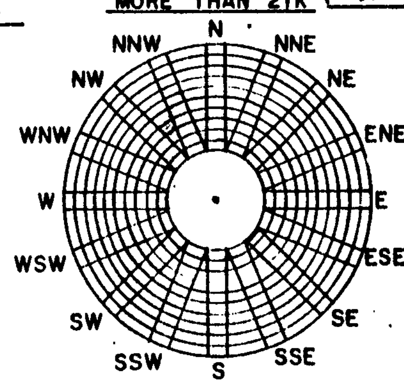
11K TO 21K (13.4 %)

SURFACE WINDS

MORE THAN 21K (.5 %)

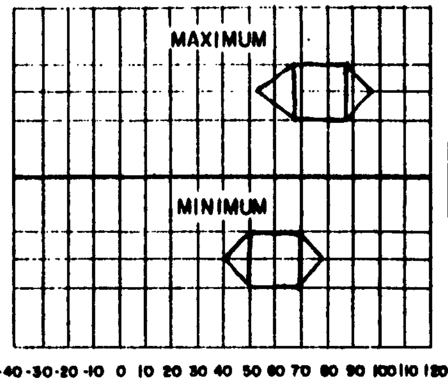


SCALE %

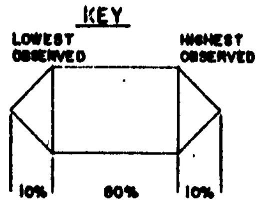


DOVER AFB CLIMATIC DATA FOR SEPTEMBER

DAILY TEMPERATURES



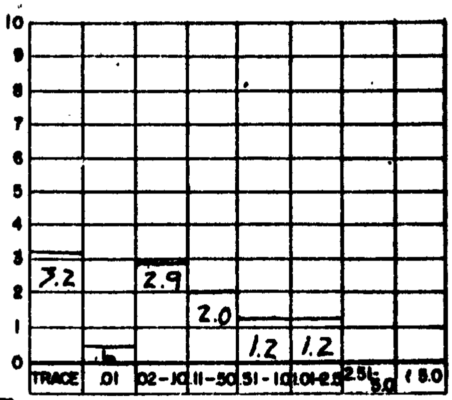
KEY



AVG PRECIPITATION 3.14 IN

AVG SNOWFALL .0 IN

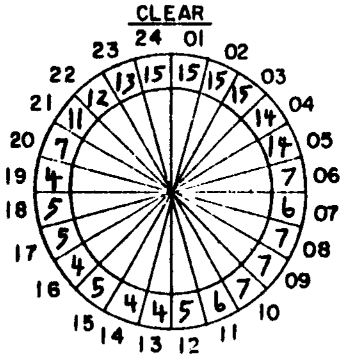
AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS



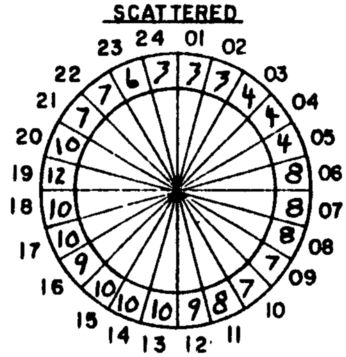
INCHES * LIQUID EQUIVALENT

TOTAL SKY COVER

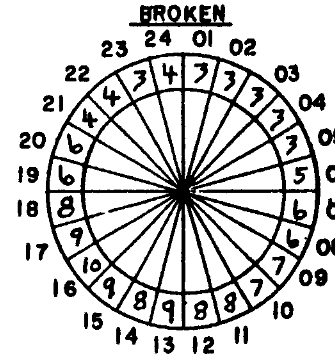
CLEAR



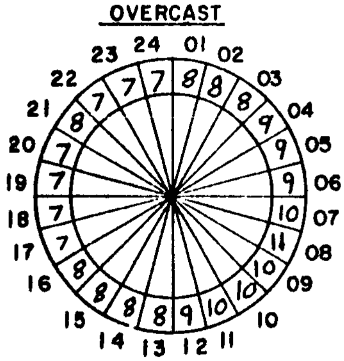
SCATTERED



BROKEN



OVERCAST

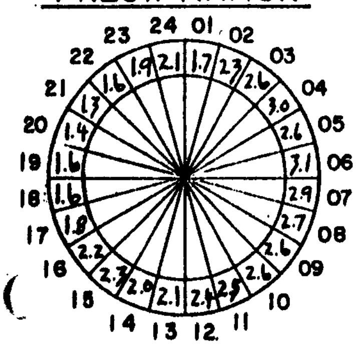


LEGEND

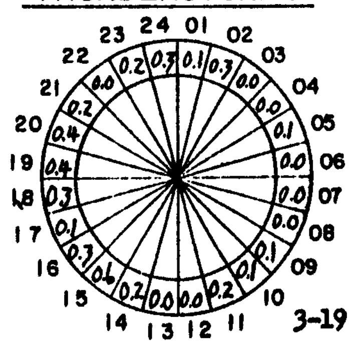
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

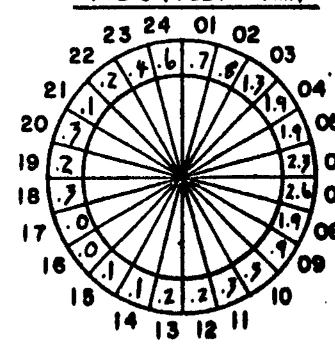
PRECIPITATION



THUNDERSTORMS



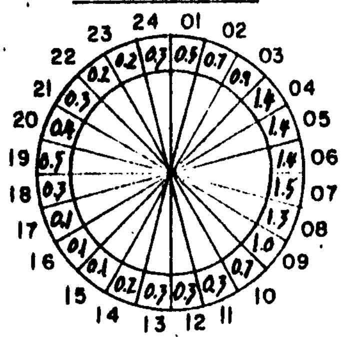
FOG (VSBY< 1MI)



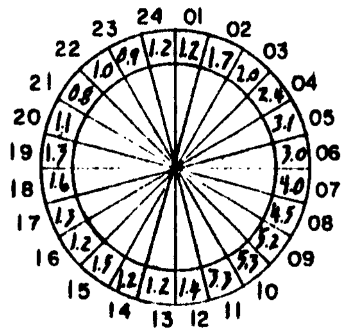
DOVER AFB CLIMATIC DATA FOR SEPTEMBER

CEILINGS

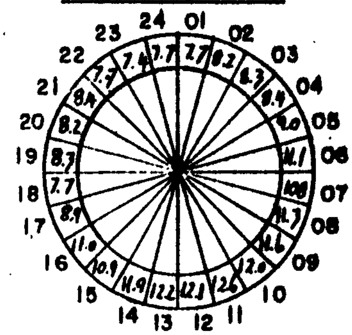
BELOW 500 FT



BELOW 1,000 FT

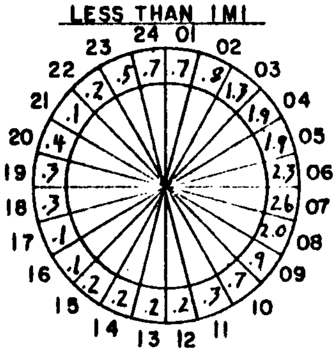


BELOW 10,000 FT

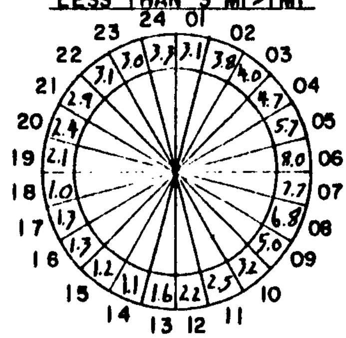


VISIBILITIES

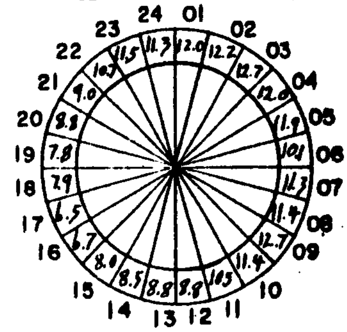
LESS THAN 1 MI



LESS THAN 3 MI > 1 MI

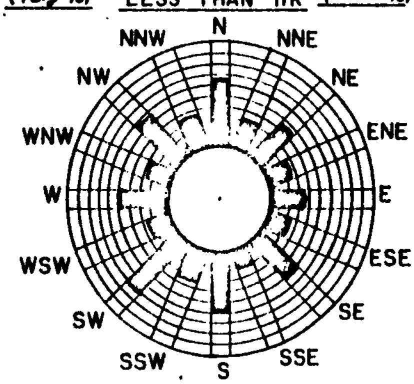


LESS THAN 7 MI > 3 MI



SURFACE WINDS

CALM (10.5%) LESS THAN 11K (68.6%)

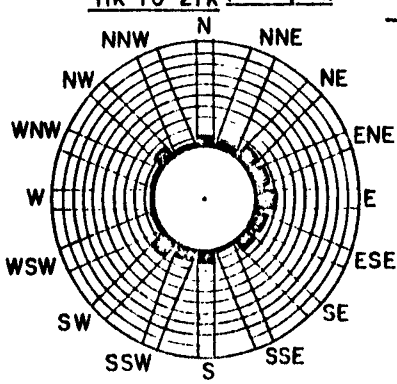


LEGEND:

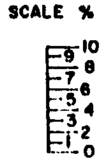
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

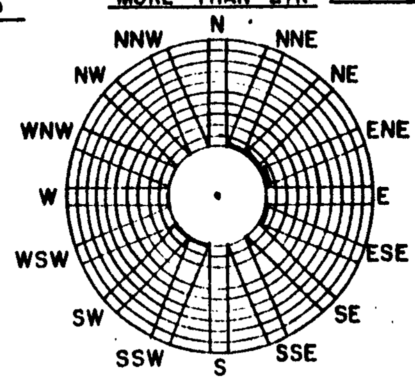
11K TO 21K (19.9%)



SCALE %

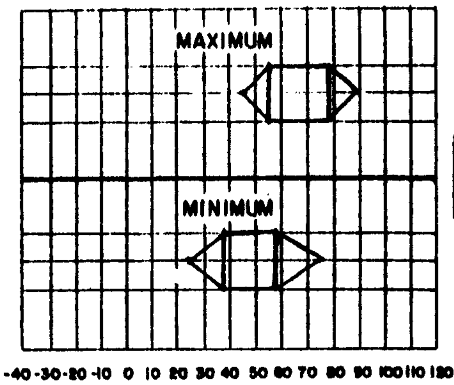


MORE THAN 21K (1.0 %)

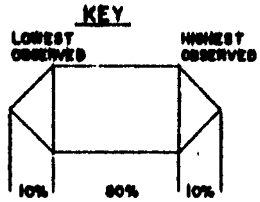


DOVER AFB CLIMATIC DATA FOR OCTOBER

DAILY TEMPERATURES



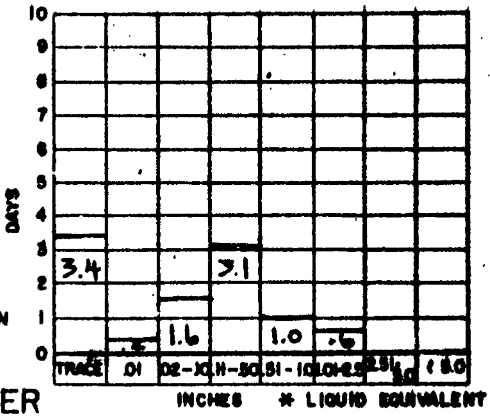
KEY



AVG PRECIPITATION 2.54 IN

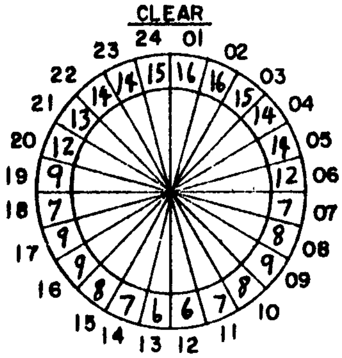
AVG SNOWFALL T IN

AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS

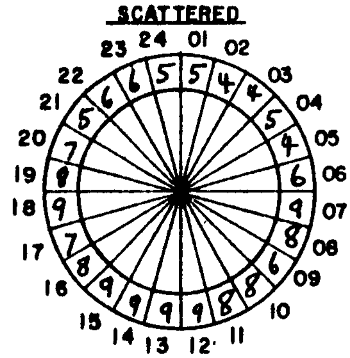


TOTAL SKY COVER

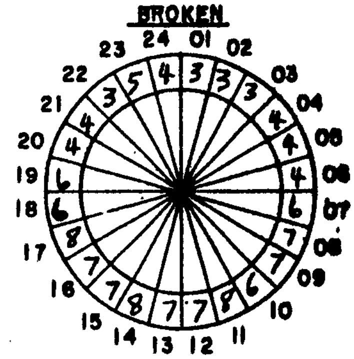
CLEAR



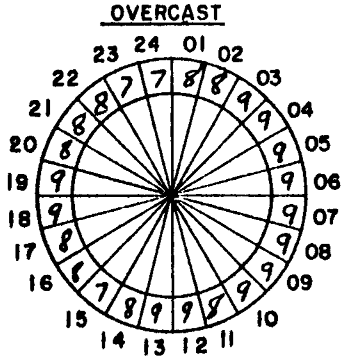
SCATTERED



BROKEN



OVERCAST

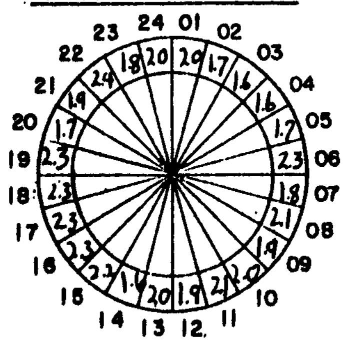


LEGEND

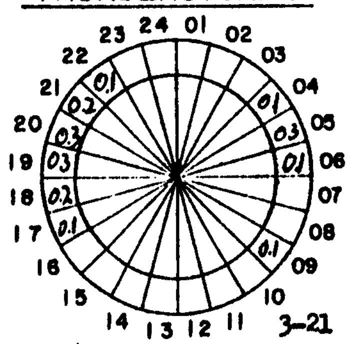
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

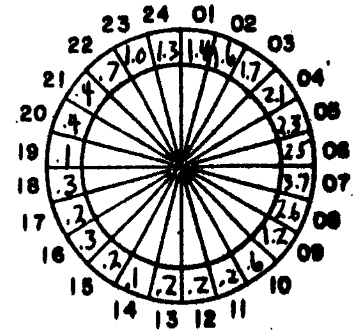
PRECIPITATION



THUNDERSTORMS



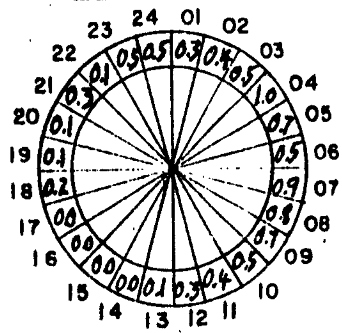
FOG (VSBY< 1MI)



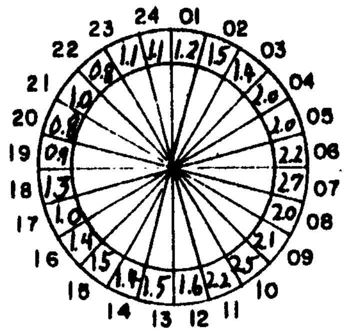
DOVER AFB CLIMATIC DATA FOR OCTOBER

CEILINGS

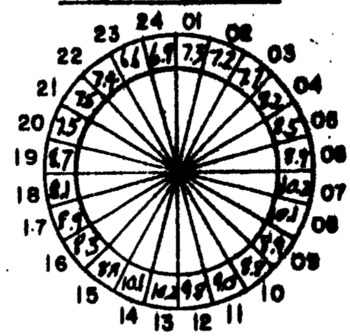
BELOW 500 FT



BELOW 1,000 FT

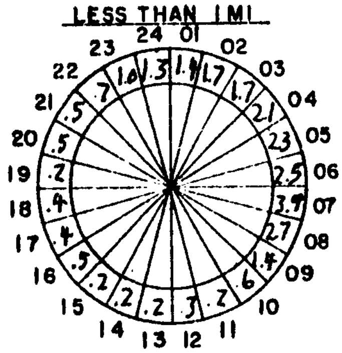


BELOW 10,000 FT

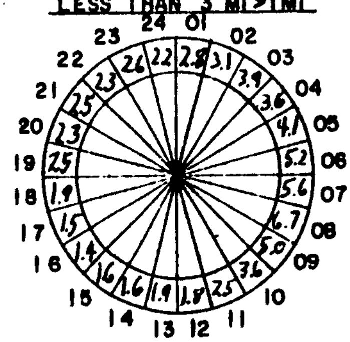


VISIBILITIES

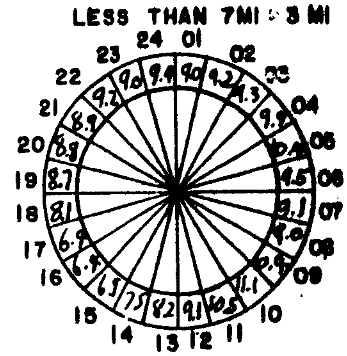
LESS THAN 1 MI



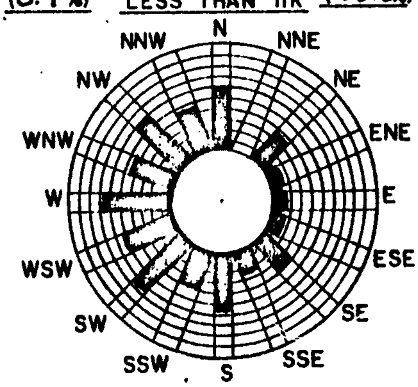
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM (8.4%) LESS THAN 11K (68.6%)



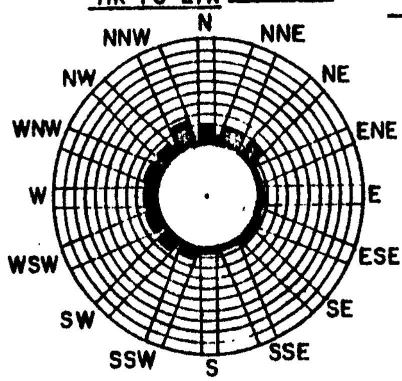
LEGEND:

FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

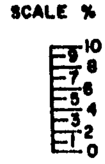
TIMES ARE LOCAL STANDARD.

SURFACE WINDS

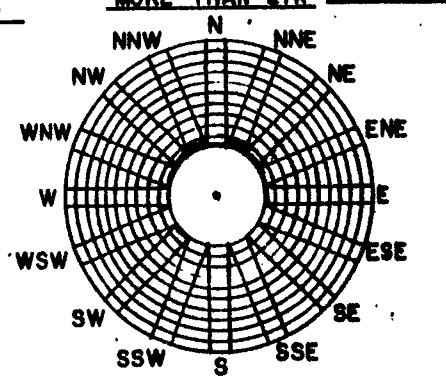
11K TO 21K (21.4 %)



SCALE %

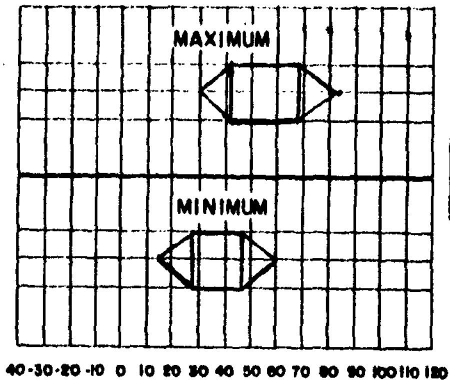


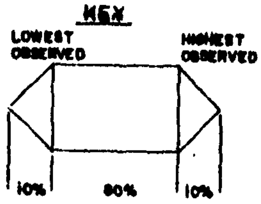
MORE THAN 21K (1.5 %)



DOVER AFB CLIMATIC DATA FOR NOVEMBER

DAILY TEMPERATURES

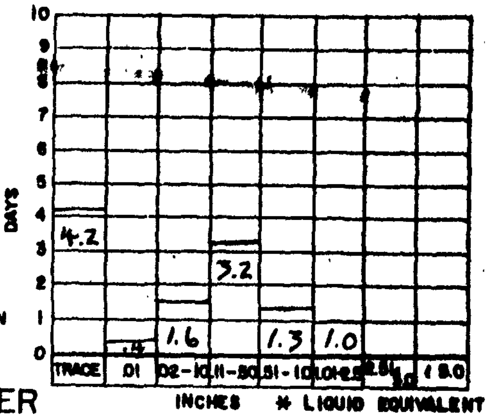




AVG PRECIPITATION 3.85 IN

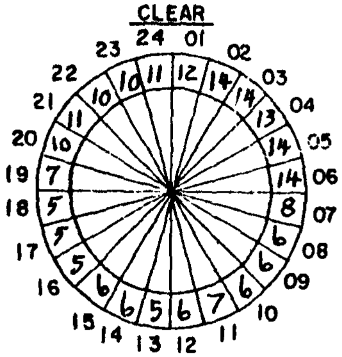
AVG SNOWFALL 1.4 IN

AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS

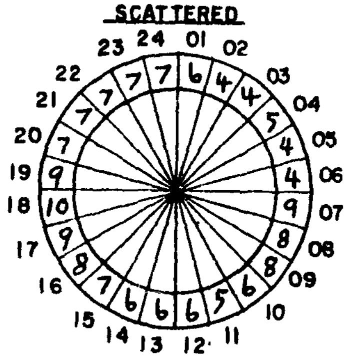


TOTAL SKY COVER

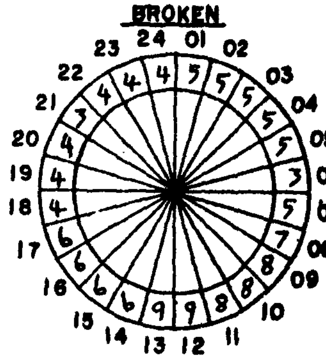
CLEAR



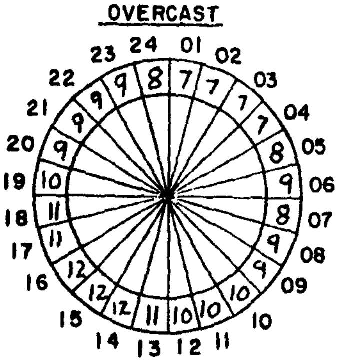
SCATTERED



BROKEN



OVERCAST

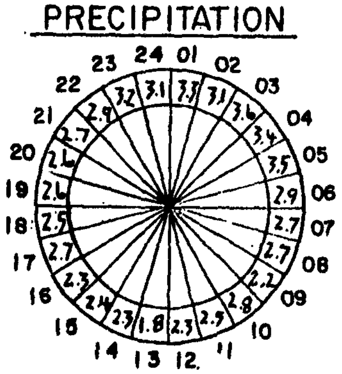


LEGEND

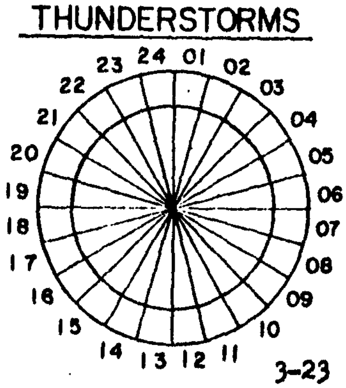
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

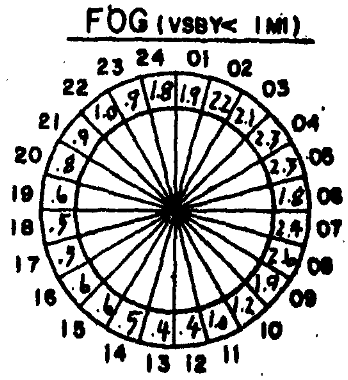
PRECIPITATION



THUNDERSTORMS



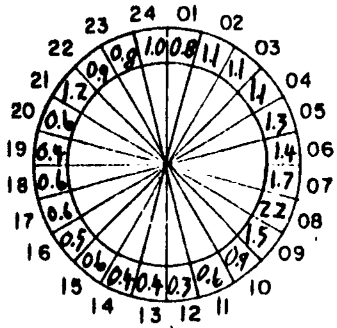
FOG (VSBY< 1MI)



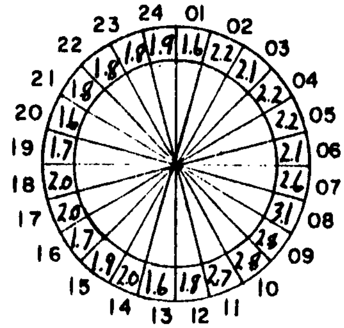
DOVER AFB CLIMATIC DATA FOR NOVEMBER

CEILINGS

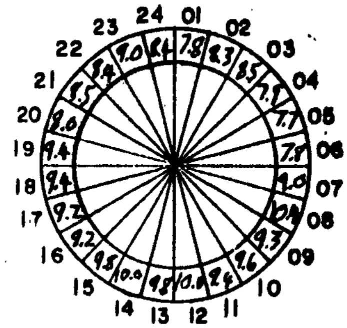
BELOW 500 FT



BELOW 1,000 FT

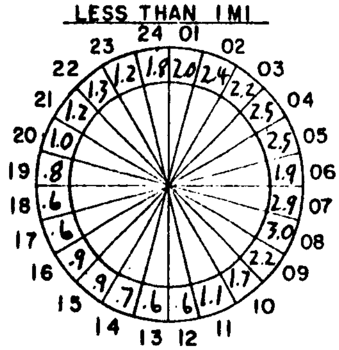


BELOW 10,000 FT

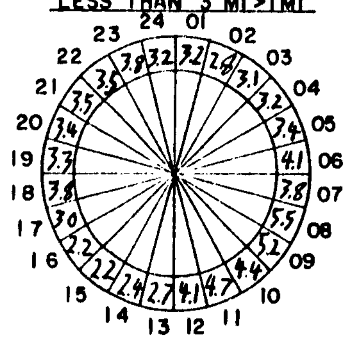


VISIBILITIES

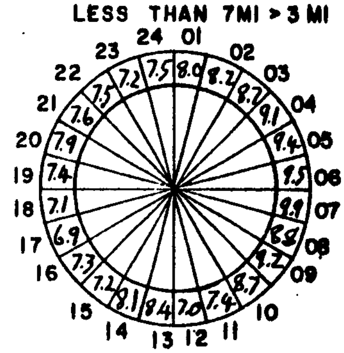
LESS THAN 1 MI



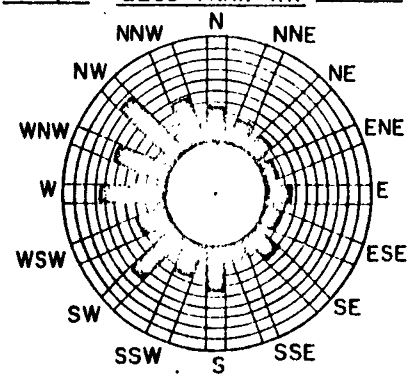
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM (10.4%) LESS THAN 11K (61.7%)



LEGEND:

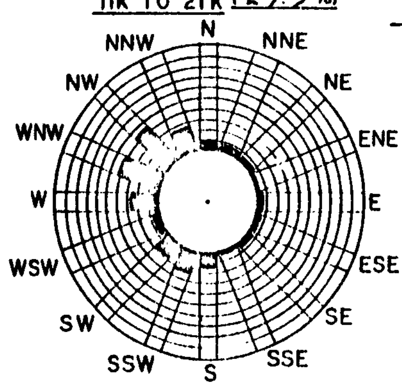
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

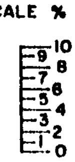
11K TO 21K (25.3%)

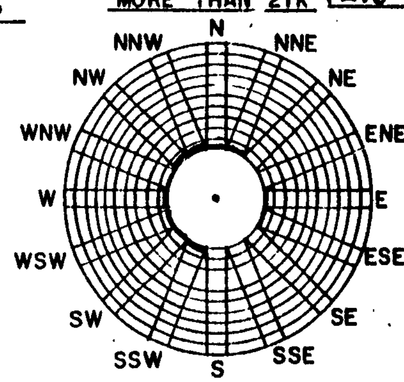
SURFACE WINDS

MORE THAN 21K (2.6 %)



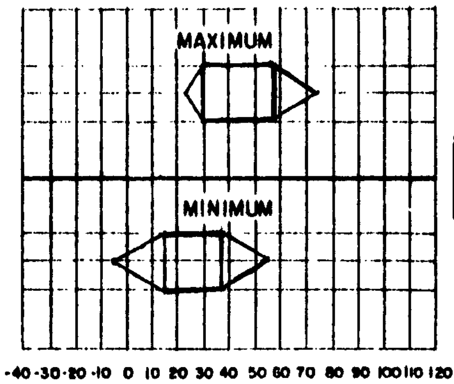
SCALE %

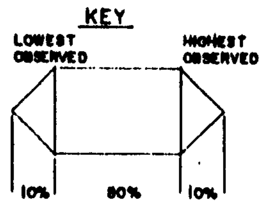




DOVER AFB CLIMATIC DATA FOR DECEMBER

DAILY TEMPERATURES

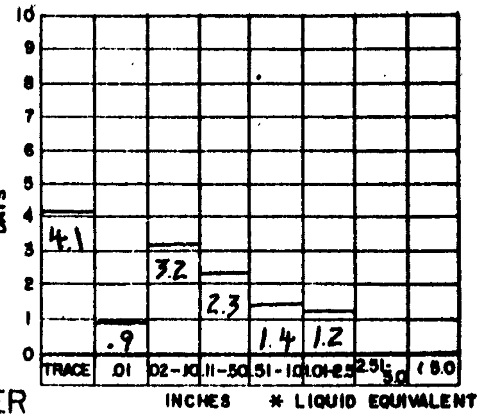




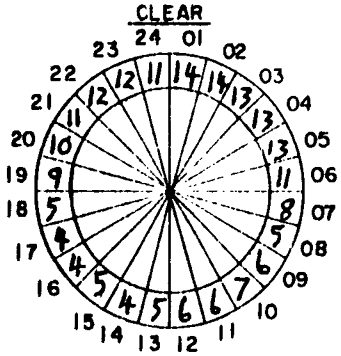
AVG PRECIPITATION 3.26 IN

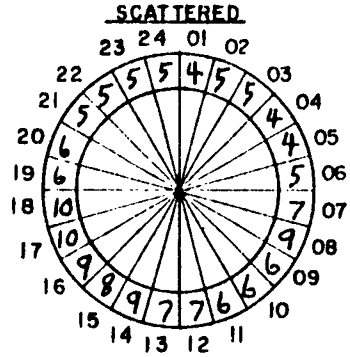
AVG SNOWFALL .2 IN

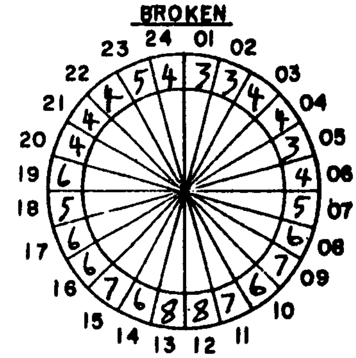
AVERAGE NUMBER OF DAYS WITH SPECIFIED PRECIPITATION* AMOUNTS

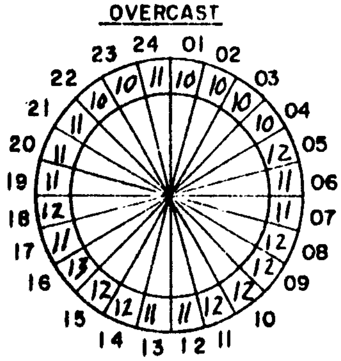


TOTAL SKY COVER







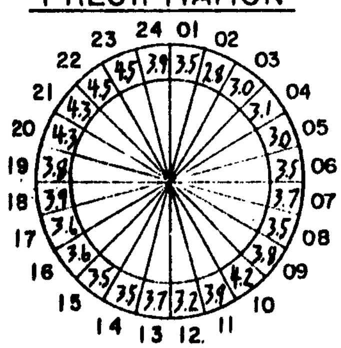


LEGEND

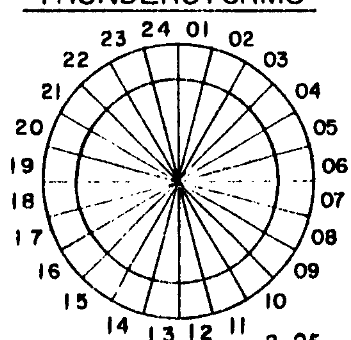
FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

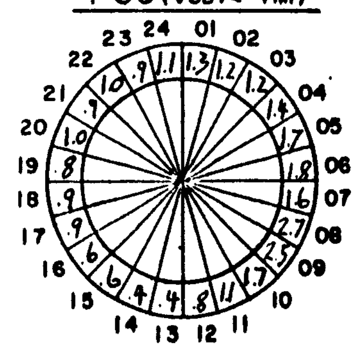
PRECIPITATION



THUNDERSTORMS



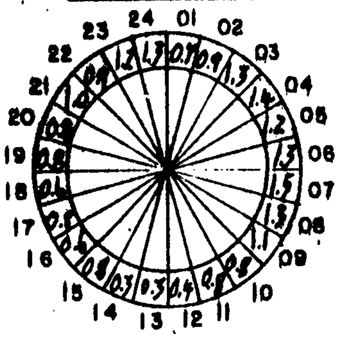
FOG (VSBY< 1MI)



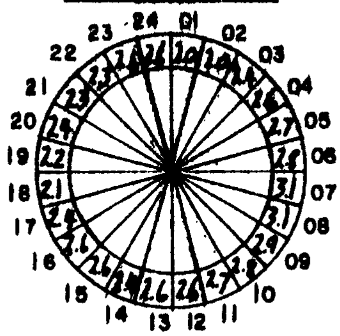
DOVER AFB CLIMATIC DATA FOR DECEMBER

CEILINGS

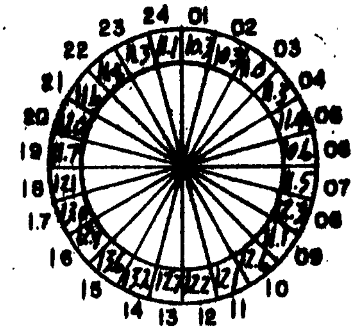
BELOW 500 FT



BELOW 1,000 FT

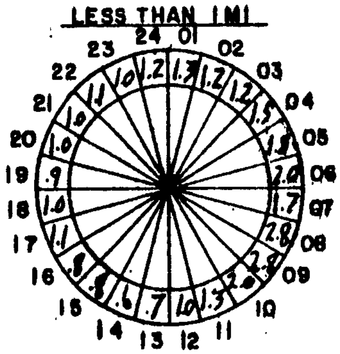


BELOW 10,000 FT

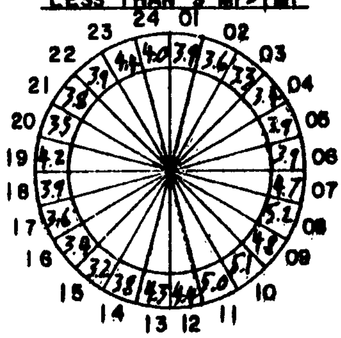


VISIBILITIES

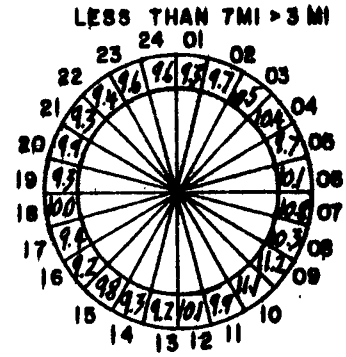
LESS THAN 1 MI



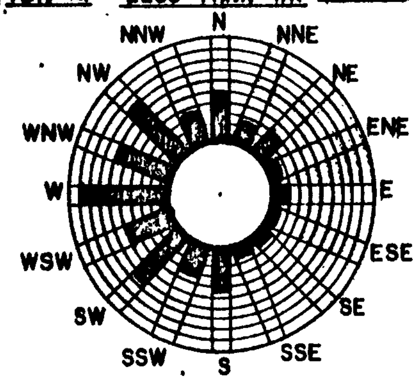
LESS THAN 3 MI > 1 MI



LESS THAN 7 MI > 3 MI



CALM (8.5 %) LESS THAN 11K (62.4 %)



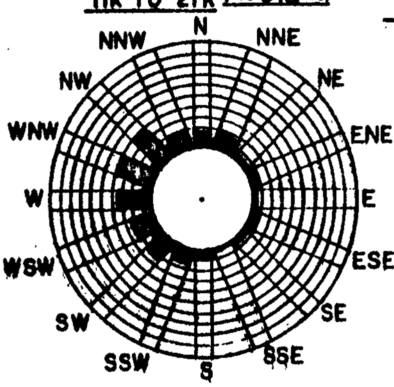
LEGEND:

FIGURES IN OUTER CIRCLE SHOW AVERAGE NUMBER OF DAYS THE SPECIFIED ELEMENT MAY BE EXPECTED.

TIMES ARE LOCAL STANDARD.

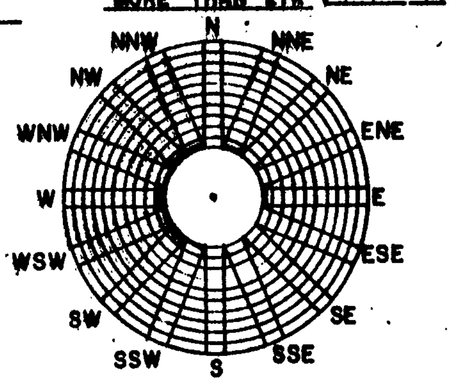
SURFACE WINDS

11K TO 21K (26.8 %)



SCALE %

MORE THAN 21K (2.2 %)



LOCAL STATISTICS

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	ANNUAL
M													
Mean Temperature: *	36.8	36.7	44.3	53.7	64.4	72.9	77.2	75.4	69.3	59.6	47.8	37.9	56.2
Absolute Maximum: #	78	82	91	99	100	102	110	107	102	97	88	76	
Absolute Minimum: #	-14	-15	4	11	26	34	43	41	31	21	8	-12	
Mean Precipitation: #	3.97	2.98	4.18	3.56	4.39	3.61	4.50	5.75	3.70	3.15	3.49	3.10	46.38

Average annual snowfall: 20 inches with an average of 20 days per year with one inch or more of snow cover (IASOR)
Average number of days with thunderstorms: 31
Average number of days with dense fog: 15
Winds of hurricane force or greater from a hurricane: Once each eighteen years.
Surface winds greater than, or with gusts greater than 25 knots are observed in about 3% of all observations.

FREQUENCY OF OCCURRENCE IN PERCENT OF OBSERVATIONS BELOW THE FLIGHT MINIMUM OF THE VARIOUS CATEGORIES OF CEILING AND/OR VISIBILITY AT DOVER A.F.B.

MINIMUM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
GCA 200/½	2.7	2.3	2.2	1.5	1.8	0.7	1.0	0.9	1.2	2.0	3.3	2.4	2.2
PPI 500/1 day	7.3	5.3	6.6	4.9	4.3	2.6	2.7	2.4	3.6	4.4	6.6	5.3	5.0
PPI 500/2 nite	12.7	10.2	10.4	8.0	6.7	4.8	5.1	6.6	7.7	8.6	11.5	10.9	8.9
IFR 1500/3	21.5	17.0	18.1	16.5	15.2	12.7	14.1	17.4	19.7	18.0	21.7	20.8	18.0
LCL 2700/5	40.4	34.8	31.9	28.0	28.6	27.4	32.0	41.6	39.8	36.6	39.0	39.9	35.2

The above data are based on 86,607 observations taken at Dover, Dec 1942–Sep 1946; Jul 1949–Sep 1949; Sep 1950–Jul 1956.

* Based on U. S. W.B. records for about 60 years for Dover, Delaware, 4 miles northwest.

\# For the State of Delaware based on U.S. W.B. records for 60 years or longer. In that Delaware is less than 100 miles long and 35 miles wide, its maximum elevation less than 400 feet, these values should be representative for the Base.

SECTION IV. LOCAL FORECAST STUDIES

SECTION IV

A. INTRODUCTION:

LOCAL FORECAST STUDIES

1. The operational weather requirements of the base are:

a. To predict, two hours in advance, ceiling and visibility of less than 200 feet and/or 1 mile visibility.

b. To predict, at least 2 hours in advance, occurrence of thunderstorm activity and severe weather associated with thunderstorm, to include hail and surface winds in excess of 35 knots.

c. To predict, six hours in advance, snowfalls of 1 inch or more within the next 24-hour period.

d. To predict, at least 2 hours in advance, gusty surface winds in excess of 35 knots and direction of surface winds to within 10 degrees.

e. To predict, at least 2 hours in advance, the occurrence of freezing precipitation, heavy frost and/or freezing temperatures, following a wet snowfall.

2. Of the above, items a, b, c are the most important and perhaps the most difficult to forecast.

3. To assist the forecaster in meeting the above operational requirements, we have developed the following reference aids:

a. Objective methods.

b. Special synoptic studies.

c. Empirical rules.

4. It should be noted that the objective techniques were recently developed. It will require several years of verification before their true value can be determined.

B. CLIMATIC SUMMARY OF SEVERE WEATHER ADVISORIES AT DOVER AIR FORCE BASE AS PREPARED BY THE USAF CLIMATIC CENTER:

CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)
Annex 2, 225 D Street, S.E.
Washington 25, D. C.

CCCAD 4025 12 Jul 61

Severe Weather Advisories at Dover AFB

9WGSS

1. Reference letter 9WGSS, 18 May 61, Request for Surface Data.

2. We have examined the WBANs from Dover AFB, Andrews AFB, and Olmsted AFB. These forms include all the dates between March 1955 and September 1960 when Severe Weather Advisories were issued. Tabulations have been made of maximum winds, peak gusts, and thunderstorm occurrences at each base. These tabulations were then compared to determine whether Dover AFB received fewer "hits" than the other bases.

3. Results of the comparisons are as follows:

a. Maximum gusts reported (% of time) when valid advisories exist -

Dover AFB - 47% of time had the maximum gusts
Andrews AFB - 35% of time had the maximum gusts
Olmsted AFB - 18% of time had the maximum gusts

b. Maximum steady wind reported as in a above.

Dover AFB - 41% of time had the maximum steady wind
Andrews AFB - 38% of time had the maximum steady wind
Olmsted AFB - 21% of time had the maximum steady wind

c. Thunderstorms reported

Dover AFB - 33% of time SWW was in effect
Andrews AFB - 33% of time SWW was in effect
Olmsted AFB - 22% of time SWW was in effect

4. A further analysis of the frequency of winds (daily peak gusts) over 35 knots was made. During the period stated there were 58 days when Severe Weather Advisories were issued; of these, there were 7 days during which Dover experienced gusts higher than 35 knots - a frequency of≈10%. However, only one of the gusts was under 40 knots, and the highest was 45 knots.

5. Conclusions from the anlyses indicate that the lack of "hits" in early 1961 was not in line with past history. While the effect of Chesapeake Bay on the Dover weather may have some bearing, there is little to go on when considering the previous years. An examination of the standard summaries for Dover and Andrews has revealed that only during May and September does Andrews have more thunderstorms than does Dover. One factor, however, may indicate a possible Chesapeake Bay influence; that is, Dover had more nocturnal-type thunderstorms than did Andrews. These data from the standard summaries are for the most part from an identical number of observations.

6. Your statement that the standard summaries indicate critical wind speeds over 35 knots occur rarely is quite right. However, these tabulations are based on steady-state (1-minute averaged) winds and do not include gusts. Using a gust factor of about 1.3-1.5 will give a steady-state wind of 25 knots, a probable gust of 35 knots. Therefore, to determine the frequency of wind speeds in the > 35-knot category, you should use the 25 knot category in the standard summaries. We feel this is justified because the peak gust will verify a wind-warning forecast.

7. From all these analyses and statements comes the final concluding advice: the most likely climatological wind forecast, when Dover is in a Severe Weather Area, is steady-state wind of 25 knots with gusts to 35 knots, with a 10% risk of gusts to 45 knots. Gusts above 45 knots should be considered only when the base commander wants a "no risk" forecast. This "no risk" wind speed is essentially the peak gust stated in the Severe Weather Advisory.

R. H. FERRELL
Deputy Director

2.

C. OBJECTIVE METHODS:

a. THUNDERSTORM FORECAST

*OBJECTIVE THUNDERSTORM FORECAST FOR DOVER AFB, DEL.

Author: 1/Lt George L. Schofield, Jr.

Date Completed: 5 September 1961

*Based on "Objective Thunderstorm Forecast for Eastern Virginia", as published in the 1961 February issue of the AWS Bulletin.

Project: Objective Forecast Study: To evaluate an objective thunderstorm prediction technique based on a study prepared for Eastern Virginia and described in the February 1961 issue of the AMS Bulletin.

Progress Report: Period 8 June to 5 October 1961.

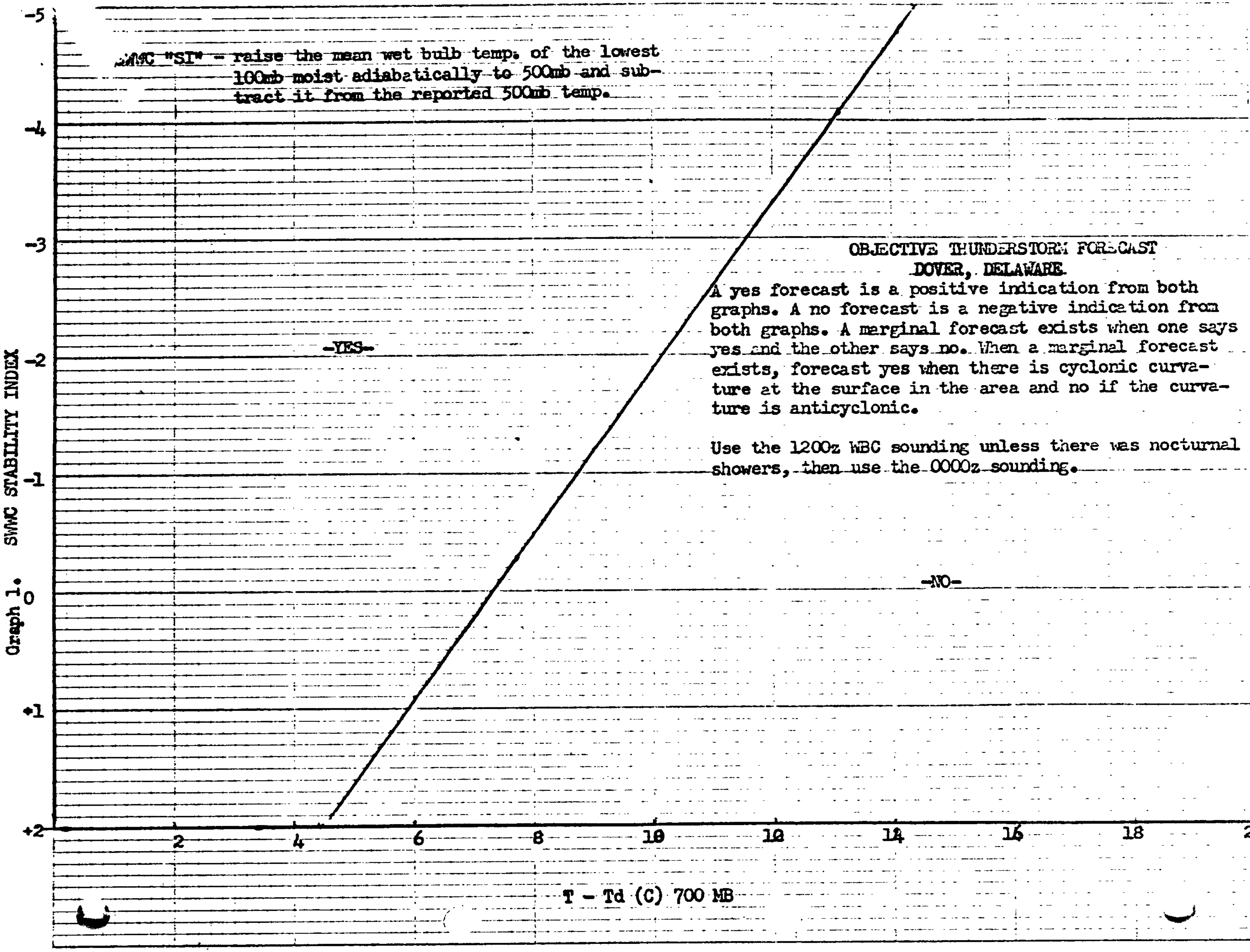
1. The 1200Z Washington sounding (DCA) was used to determine two parameters which were extracted from a nomogram in a yes or no form. (Attachment 1& 2)

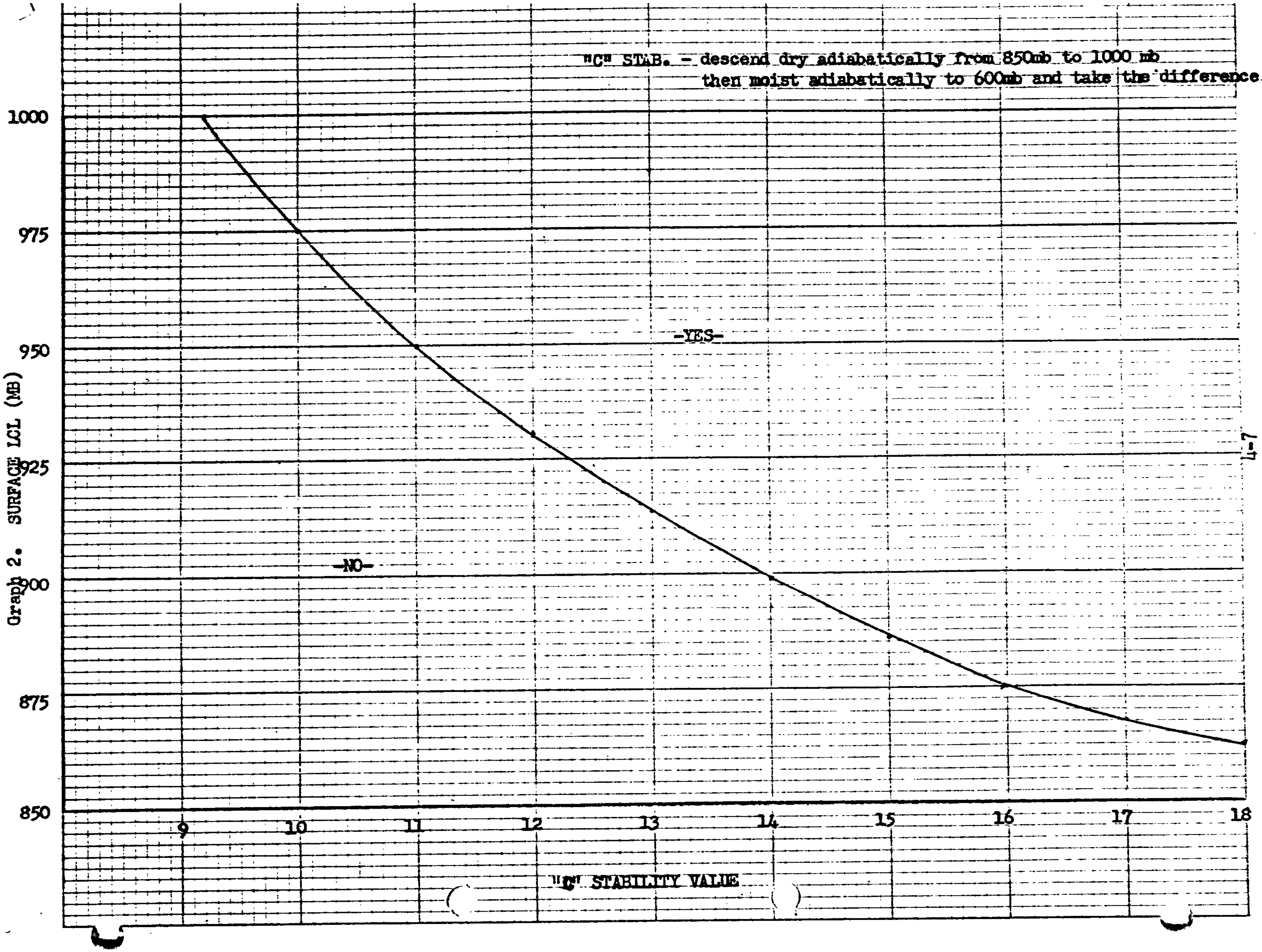
2. The following is a summary of the verification of this method:

Nr of Cases	Forecast Yes	Forecast No	Observed Yes	Observed No	Remarks
17	X		X		Thunderstorms within 20 MI of Station included.
10	X			X	
21		X		X	
1		X	X		
8	X	X		X	Nomogram indicated yes and no. Two cases of yes on SWC "SI" side verified as Tsm. Six cases did not verify.

Findings: 1: This objective technique is very good for forecasting thunderstorms in the Dover area during the period June through September. The initial verification of 25 cases during the period 8 June to 9 August was 80 percent. The overall verification through 5 October 1961 was only 66 percent. The reduced verification is due to the larger number of "busts" in September. Therefore, we believe the study should be confined to the summer months of June through September.

Findings: 2: A yes and no forecast did not verify. Therefore, when a yes and no answer is indicated, the forecast should be no with the following exception: A yes on graph one with strong cyclonic curvature at the surface, forecast yes.


Graph 1. SWWC STABILITY INDEX
SWWC "SI" - raise the mean wet bulb temp. of the lowest 100mb moist adiabatically to 500mb and subtract it from the reported 500mb temp.
-YES-
-NO-
OBJECTIVE THUNDERSTORM FORECAST
DOVER, DELAWARE
A yes forecast is a positive indication from both graphs. A no forecast is a negative indication from both graphs. A marginal forecast exists when one says yes and the other says no. When a marginal forecast exists, forecast yes when there is cyclonic curvature at the surface in the area and no if the curvature is anticyclonic.
Use the 1200z WBC sounding unless there was nocturnal showers, then use the 0000z sounding.
-5
-4
-3
-2
-1
0
+1
+2
2
4
6
8
10
12
14
16
18
20
T - Td (C) 700 MB


"C" STAB. - descend dry adiabatically from 850mb to 1000 mb
then moist adiabatically to 600mb and take the difference
1000
975
950
925
900
875
850
-YES-
-NO-
9
10
11
12
13
14
15
16
17
18
"C" STABILITY VALUE
Graph 2. SURFACE LCL (MB)

Project: Objective Forecast Study: To evaluate an objective thunderstorm prediction technique based on a study prepared for Eastern Virginia and described in the February 1961 issue of the AMS Bulletin.

Progress Report; Period 27 April through 31 August 1962.

1. The following is a summary of the verification over the above period:

Nr of Cases	Forecast		Observed		Remarks
	Yes	No	Yes	No	
32	X		X		Thunderstorms within 20 miles of station included
9	X			X	
71		X		X	
4		X	X		
3	X	X		X	Nomogram indicated yes and no.

Findings: Verification 86%. Even if we excluded the 71 cases of "No" Forecast - "No" Observed (assuming that we wouldn't have forecast thunderstorms even without the objective technique) verification is 66 percent.

C. OBJECTIVE METHODS: (Continued)

b. SNOW FORECASTING ALONG THE EAST COAST

"Snow Forecasting Along the East Coast with Technique for Predicting Snowfall at Dover Air Force Base"

Author: 1/Lt Joseph A. Ships, Jr.

Date Completed: 28 November 1961

SNOW FORECASTING ALONG THE EAST COAST

Prepared By

Lt Joseph A. Shipe, 28 Nov 61

I think the following quote from J. J. George aptly describes the problem. "Ranking next to fog, heavy snowfall (snowstorms) cause the greatest amount of operational difficulties to aviation, both military and commercial. To the general public, they are without doubt the worst common manifestation of the weather; to the forecaster, they seem to be the "ultimate expression" of the weather elements, because of the complexity and number of factors involved in their formation and prediction."

It has been found that most major snowstorms are closely associated with strong troughs of the main jet stream approaching the boundaries of sharply contrasting air masses, and the resulting major surface cyclone. However, because of the infrequency of major snowstorms at any one location in the U.S., local forecasters have very little experience to call on for what may be their most important assignment. It is the purpose of this seminar to join together the latest research results of cyclone intensification with those of precipitation quantities and types for a general heavy snowstorm-forecasting guide over the northeastern U.S. To accomplish this, two forecast methods and a list of rules of thumb will be discussed. The first method is a general forecast guide for snows of 10" or more and the second is a method developed for Washington, D.C., that can be adapted for use here. The Washington method is for snows of 5 inches or more.

The heavy snow forecast study was prepared by R. E. Bailey and is reproduced in George's text, "Weather Forecasting for Aeronautics".

The forecasting data were chosen so that the heavy snow generally fell during the second half of a 24-hour forecast period. With the causes of the heavy snow determined in this period, forecasting parameters defining a heavy snowstorm can be anticipated by an experienced forecaster an addition 12 hours ahead, making a 24-36 hour forecast quite feasible. The southern geographical limit of heavy snowstorms coincides quite well with the annual ten inch snowfall line. They are, however, extremely rare south of the 20 inch annual line shown and should be forecast south of this line only under the most favorable conditions.

The forecasting of cyclone deepening is closely associated with trough movements and vorticity advection at upper levels, cold air advection at lower levels and the presence of sufficient moisture in close proximity to a deep cold air mass.

Over a period of eight winters, November 1949 through April 1957, some 132 synoptic situations were investigated which gave moderate-to-heavy snow from low centers. Hundreds of smaller cyclones, or low moisture situations, were eliminated even if they produced 6 to 8 inches of snow. In like manner, all of the Great Lakes' air mass snowstorms of late autumn and early winter were eliminated. Some 56 major snowstorms were included; a sufficient number to establish a set of minimum synoptic conditions to guide the forecaster and to enable him to avoid over-forecasting to a dangerous degree. These conditions, starting aloft, were as follows.

1. 500 mb: At least a 70-knot observed isotach maximum blowing through the trough. Including at least a 10°C isotherm ribbon of not more than 300 miles width and the trough moving eastward with a speed of at least 20 knots.

2. 850 mb: Cold air advection in the southwest quadrant of the surface low and not more than 1000 miles away.

3. Surface: All the major storms reach at least a 20 count. The term count is used to define cyclone intensity. This is the sum of the gradient in mb, measured 600 miles in each cardinal direction from the low center, divided by 4.

Now let us amplify these conditions at each level and find out what information is needed. At the 500 mb level, the isotach max and isotherm ribbon were usually located west or southwest of the surface low to be deepened, at an average distance of about 500 miles. Another important factor in predicting these severe snowstorms is the concept of diffluent contours measured at 500 mb. Such diffluent contours over the surface low are present in a good majority of the heavy snowstorms.

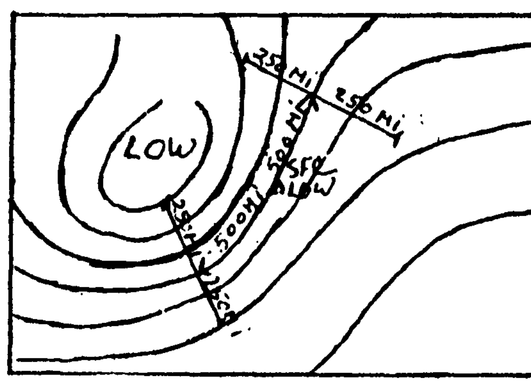
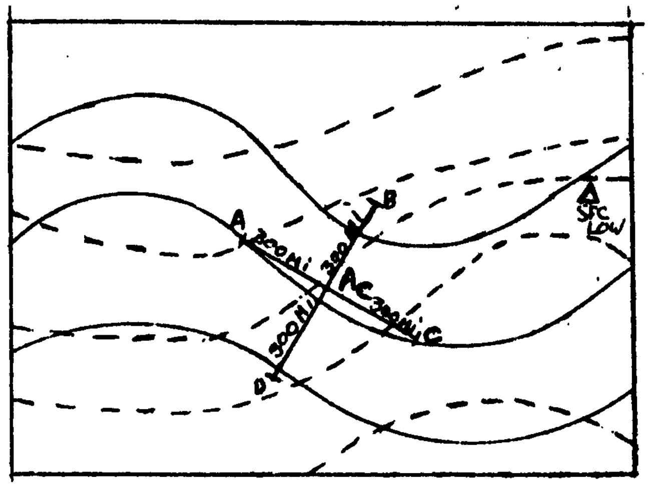


Illustration of Diffluent Contours at 500 mb level

In the above illustration, the downstream contour space count is about 3.5. The upstream count is about 5.5. The ratio of the upstream count to the downstream count is called the "diffluence ratio", and here amounts to about 1.6. When the ratio reaches 1.5, the surface low begins to "slip out of gear" with the steering flow aloft, slows down, curves to the left into colder air, and causes heavy snow. When the ratio reaches 2.0, these effects become pronounced and often lead to capturing of the surface low.

A special feature to notice is the occasional appearance of a concentrated isotach max far up the west side of a 500 mb trough. It usually shows 100-knot winds and a 300 mile wide isotherm ribbon of 15°C or more, bordering temps, well below -30°C in the trough. These features are the reflection of an intense isotach max, possibly as large at 200 knots in the overlying jet-stream core, which will race through the trough within 24 hours and often creates a major storm in 30 to 36 hours.

Moving down to the 850 mb level, it was found that the necessary cold advection for all major cyclones can best be measured here. The cold advection center is determined from open contours going through the trough.



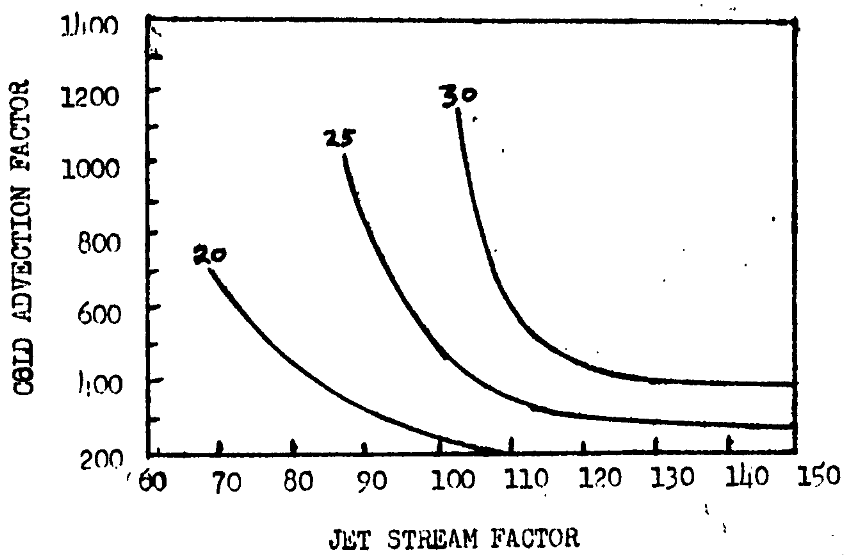
Location of an 850-mb or 700-mb
Cold Advection Center, marked "A_c."

This center, Ac in the illustration, should always be in the southwest quadrant of the surface low, and not more than 1000 miles away. The wind through Ac must be at least 20 knots and the isotherm field A-C at least 10°C. The product of the 2 parameters obtained should not drop below 250. In the case of a cold advection center at the extreme range of 800-1000 miles, a product of at least 400 to 450 is needed.

Lastly, we come to the surface conditions. In nearly all potential heavy snow situations, a low is already present under southwest flow aloft. For heavy snow, a low of initial count less than 20 mb should intensify by at least 10 mb in the succeeding 24 hours to a minimum count of 20, unless the center is initially 17-19 count and deepens to a 20- plus storm. All snow producing storms deepening to a 30 count are heavy and of the blizzard type. A minimum surface dewpoint of 40°F must be observed within 300 miles of the low in the warm sector at forecast time. If a low is already captured, that is, within 250 miles of a 500 mb cold low center, the heavy snow stage is usually over. However, if the system remains stationary, a light to moderate rate of snow may accumulate large amounts over a 24 to 48 hour period. It should be stressed that if a deepening low is expected to go into the capturing process, it will usually produce a heavy snowstorm while being captured.

The heavy snow area is usually located in the northwest quadrant of the low, with its western boundary near the 700 mb trough line. This rule applies to all lows starting under diffluent contours at 500 mb, but for storms moving under straight contours aloft, the snow will fall in a 100-200 mile strip to the left of the predicted track, taking place in the north quadrant of the low.

The following cyclone deepening graph combines the important vorticity advection and cold advection factors in one simple diagram that requires only a few minutes for the computation of cyclone intensity 24 hours in advance. The graph clearly defines the great storms that deepen beyond a 25 count, along with the



A 24 hr Cyclone-Intensity Prediction Graph

east coast cyclongenesis of explosive proportions which reach a 20 count within 18 hours.

The attached worksheet should be used to list the minimum conditions at each level.

WORK SHEET 30

HEAVY SNOWSTORMS

The method of forecasting heavy snowstorms is by a process of combining synoptic factors which meet a series of experimentally determined minimums, as discussed in the body of the text.

1. Minimum Requirements at 500 mb

a. Trough located 300 to 700 miles west of surface low center.....________

b. Stop here if trough is filling, or maximum winds east of trough are generally twice as strong as those west of trough.

c. Isotach maximum of 70 knots or more with a 10°C isotherm ribbon (300 miles wide) in trough W or SW of surface low. Divide maximum wind by 10 and square this figure.......................________

d. Trough movement 20 knots or more during past 12 hr, or forecast acceleration rate if indicated. Add to answer from step "C" and enter Cyclone Deepening Graph (Fig. 15.6) with sum.............________

e. Diffluence ration of contours over surface low center of at least 1.5 to 1 is frequent but not necessary.......................________

f. Special Case: 100-knot isotach maximum with 15°C isotherm ribbon on west side of trough should be used for trough measurements as it catches up to main trough.

2. Minimum Requirements at 850 mb and 700 mb

a. Location of probable snow area by location of 850-mb 0°C isotherm, usually associated with blocking surface high in immediate future path of cyclone precipitation pattern.

b. Cold advection center, A_c, showing at least 20-knot flow of at least 10°C over 600-mile range. Product minimum 250. A_c located within 1000 miles (usually less than 800 miles) of surface low in SW quadrant. Enter product on Cyclone Deepening Graph.....________

c. Cold advection factor at 700 mb over Rocky Mountains if 850 mb does not apply, using same measurements as step "b"...........________

d. Locate maximum dewpoint at 850 mb within 300 miles of surface low center. Should be at least -4°C........................________

3. Minimum Surface Requirements

a. Use Cyclone Deepening Graph for forecast cyclone intensity within 24 hr.

(1) Initial low count. Should be less than 20 mb, using 600-mile radius for LaPlacian measurement......................________

(2) Twenty-four-hr forecast of cyclone intensity from graph should show at least 10-mb deepening from pervious step, except lows already 17-19-mb count.......................________

(3) Final count in 24 hr should be 20 mb or more.

(4) Add 5-mb deepening to Step (2) for lows starting along East Coast over ocean....................................________

(5) Forecast track. Should be north of 60°. Exception: A 25 or more count forecast under parallel 60-70°, 500-mb contours with surface and 850-mb dewpoint minimums 45°F and 5°C, respectively, within 300 miles of low center...________

(6) All lows under diffluent contours at 500 mb will tract 360° to 50°.

(7) All forecast 30-mb-count cyclones with minimum moisture requirements at 850 mb and surface.

b. Locate dewpoint maximum within 300 miles of low center. Should be at least 40°F..________

c. Surface low should not be captured (within 250 miles of 500-mb low), unless forecast to remain nearly stationary, thereby causing long duration of a light-to-moderate snow rate in one location.

The second method combines semi-objective methods of prediction for major snowstorms in Washington, D. C. with a deep sample of experience of such storms as represented by some 59 occasions when heavy snow occurred. In this study, a major storm is defined as one which produces an accumulation of 5 inches or more of snow.

Although each situation has features not common to the others, a general synoptic pattern does evolve and the outstanding features of this general synoptic picture are as follows:

SURFACE MAPS:

The general development of "Snowstorms" along the northeast coast are the result of the following sequences, listed in the order of their frequency:

1. Cyclogenesis along the east coast with the storm center deepening and moving northeast off-shore between Hatteras, N.C. and Nantucket, Mass.

2. Cyclones in the Gulf States or in the Gulf of Mexico which deepen and move northeast and track along the coast line from Hatteras, N.C. and Nantucket, Mass.

3. Cyclones moving eastward through the Ohio Valley and crossing the coastline between Hatteras, N.C. and New York City.

The surface pressure patterns which favor snow over rain in the northeast coastal area, display a strong anticyclone over or just north of the Great Lakes area and low pressure over the Nova Scotia area.

850 MILLIBARS:

In order to prevent the air at this level over the northeast from being warmed above the freezing point, the zero degree isotherm should be well south of the stations along the coastline. This is particularly true when southerly flow is established over the stations for some time before the start of precipitation. If the zero degree isotherm is close to the stations involved, snow will not occur unless it occurs simultaneously with the passage of the ridge line to the east of the station. In many of these cases, the ridge line is situated across Pennsylvania 12 hours before the onset of snow, with the northern boundary of the snow area marked by the 850 mb ridge line. The strongest warming in the area under study, occurs when the zero isotherm is oriented NW-SE across the Ohio Valley with west-southwest winds across it indicating warm advection.

In order to accurately predict snowstorms for a given locale, the following meteorological items must be determined:

1. Will the precipitation occur in the form of snow?

2. The intensity of the snowfall.

3. The onset and cessation of snowfall.

This study deals principally with items one and two, although a solution is presented to determine the duration of moderate and heavy snow.

The type of precipitation is determined through graphic multiple correlation based on objective parameters. The solutions are for period of 24 and 12 hours from data time to the onset of precipitation. The parameters are taken from the surface and 850 mb charts nearest to 24 and 12 hours before the start of the precipitation.

The temperature of the lower atmosphere determines the type of precipitation reaching the ground. Essentially, a correct forecast of the temp at the surface and at the 850 mb level, will predict precip types. The method used here is an indirect temp forecast for these levels with the final solution expressed in terms of precip types. George, in 1947, developed a pattern method to determine the type of precipitation likely to occur at New York City, associated with Atlantic secondary storms. This method is satisfactory when the patterns are well defined, but presents difficulties in more obscure situations. This objection to the pattern method can be overcome by numerically indexing the patterns with objective measurements of surface pressure. The usual surface pressure pattern associated with snow in the northeast coastal area of the U.S. displays high pressure to the north of the Great Lakes with low pressure over the Nova Scotia and New Foundland areas. This arrangement of pressure systems provides general northerly flow through eastern Canada and the eastern Great Lakes area with westerly or northwesterly flow through New England. As a measure of this circulation pattern, the surface pressure difference between Green Bay, Wisconsin and Portland, Maine, ($P_{grb}-P_{pwm}$), is used to evaluate the flow through eastern Canada and the eastern Great Lakes area. The flow index so obtained is plotted against the sum of the surface temp and dewpoint in the first stage of multiple correlation. The sum of the temp and dewpoint is used as a quick approximation proportional to the wet bulb temp.

The second phase of the multiple correlation involves the 850 mb level. The major factor at 850 is warming. Therefore, it becomes necessary to measure the zonal advection at 850 over a large area. Advection of warmer air into the northeast coastal area for the layer between the surface and 850 is associated with the breakdown of high pressure and the increase in low level thickness through eastern Canada and the eastern Great Lakes area. However, strong warming at 850 just prior to precipitation is quite rare. The maximum warming during the 24 hour period preceding precip at Washington is 7°C. Temps below -7°C will indicate snow if precip is to occur within 24 hours. If the air mass is extremely cold, the current 850 temp is a very good forecast parameter, however, in the range from near zero to -4°, it becomes quite obscure. The advection at 850 plotted against the present temp, is the second stage of the multiple correlation.

The method of determining the advection is based on a series of measurements of the flow and temp fields at 850. The net zonal component of the flow through a large portion of eastern Canada and the eastern U.S. is obtained by measuring the difference in height, in tens of feet, between Greensboro, N.C. and Moosonee, Ont., ($GSO_{z850} - MO_{z850}$). Positive values will indicate a net west wind with negative values indicating a net east wind. The east-west temp gradient at approximately the mid-point of the line used to determine the zonal flow index is measured by determining the temp difference between Albany, N.Y. and Flint, Mich., ($ALB_{T850} - FNT_{T850}$). The product of the zonal flow index and the east-west temp index is used to obtain units of zonal advection, $(GSO_{z850} - MO_{z850}) \times (ALB_{T850} - FNT_{T850})$. Positive values indicate cold advection.

The net meridional flow across the Great Lakes to the northeast coast is measured by the difference in height between Green Bay, Wis. and Portland, Me., $(GRB_{Z850} - PWM_{Z850})$. Positive values will indicate a north wind and negative a south wind. The north-south temp gradient across this line at approximately the mid-point is determined by measuring the difference in temp between Pittsburgh and Maniwake, Quebec, $(PIT_{T850} - MW_{T850})$. The product of the meridional flow index and the north-south temp index, $(GRB_{Z850} - PWM_{Z850})(PIT_{T850} - MW_{T850})$, is used to obtain units of meridional advection. Positive values indicate cold advection and negative warm advection.

The total advection is the sum of the zonal and meridional advection with positive values indicating net cold advection and negative indicating net warm advection. $(GSO_{Z850} - MO_{Z850})(ALB_{T850} - FNT_{T850}) + (GRB_{Z850} - PWM_{Z850})(PIT_{T850} - MW_{T850})$

The final solution is obtained in stage 3, in which the value of the stage 1, or surface data, is plotted against the value of stage 2 or the 850 mb. data. The parameters are obtained in identical fashion for both 24 and 12 hours. Following are the charts for 12 and 24 hours, with a map and worksheet:

The Stage One Graph is based on surface data. The flow index is obtained by subtracting the pressure at Portland, Maine from the pressure at Greenbay, Wisconsin. $(P_{GRB} - P_{PWM})$

The Stage Two Graph is based on 850mb data. The advection factor is obtained through the following computation;

$$(GSO_Z - MO_Z)\ (ALB_T - FNT_T) + (GRB_Z - PWM_Z)\ (PIT_T - MW_T)$$

The Z values are expressed in tens of feet.
The T values are expressed in degrees centigrade.
The final sum is expressed in hundreds of units.

In The Third Graph the plotted letters have the following significance:

R - Rain	E - Sleet	RS - Rain & Snow
S - Snow	ZR - Freezing Rain	ER - Sleet & Snow

The arrows connecting two letters indicate a change from one form of hydrometeor to the type indicated by the point of the arrow. Points falling in the lower right zone of the graph indicate snow as the proper forecast, whereas points falling in the upper left zone indicate rain as the proper forecast. The central portion of the graph bounded by the two heavy curves represents the transition zone from rain to snow. Since this constitutes an area of uncertainty, the proper forecast in this zone should be a combination of rain and snow.

WORK SHEET FOR SNOWSTORMS AT DOVER, DEL.

This work sheet should be used after the starting time of precipitation has been predicted. The computations are made from the surface and 850 mb charts nearest to 24 and 12 hours before the start of precipitation at Dover, Del.

THE VALUES CAN BE ENTERED IN EITHER THE 24 OR 12 HOUR CHARTS, DEPENDENT ON THE TIME INTERVAL BETWEEN THE CURRENT CHARTS AND THE FORECAST TIME OF PRECIPITATION.

1. Subtract the surface pressure at Portland, Me. from the surface pressure at Greenbay, Wis. ($P_{GRB}-P_{PWM}$) ________

2. Note the sum of the surface temp. and dewpoint at Dover, Del. ________

3. Enter the values from steps (1) and (2) in stage one of the forecasting graphs and record the value indicated by the weight lines. ________

4. Note the temp. at Dovr, Del. on the 850 mb chart. ________

5. At 850 mb subtract the height at Moonsonee, Ont. from the height at Greensboro, N.C. and record in ten's of feet. $GSO_{Z850}-CYMO_{Z850}$ ________

6. At 850 mb subtract the temp. at Flint, Mich. from the temp. at Albany, N.Y. ($ALB_{T850}-FNT_{T850}$) ________

7. Multiply the values obtained in steps (5) and (6). ________

8. At 850 mb subtract the height at Portland, Me. from the height at Greenbay, Wis. and record in ten's of feet. $GRB_{Z850}-PWM_{Z850}$ ________

9. At 850 mb subtract the temp. at Manawaki, Que. from the temp. at Pittsburgh, Pa. ($PIT_{T850}-CHW_{T850}$) ________

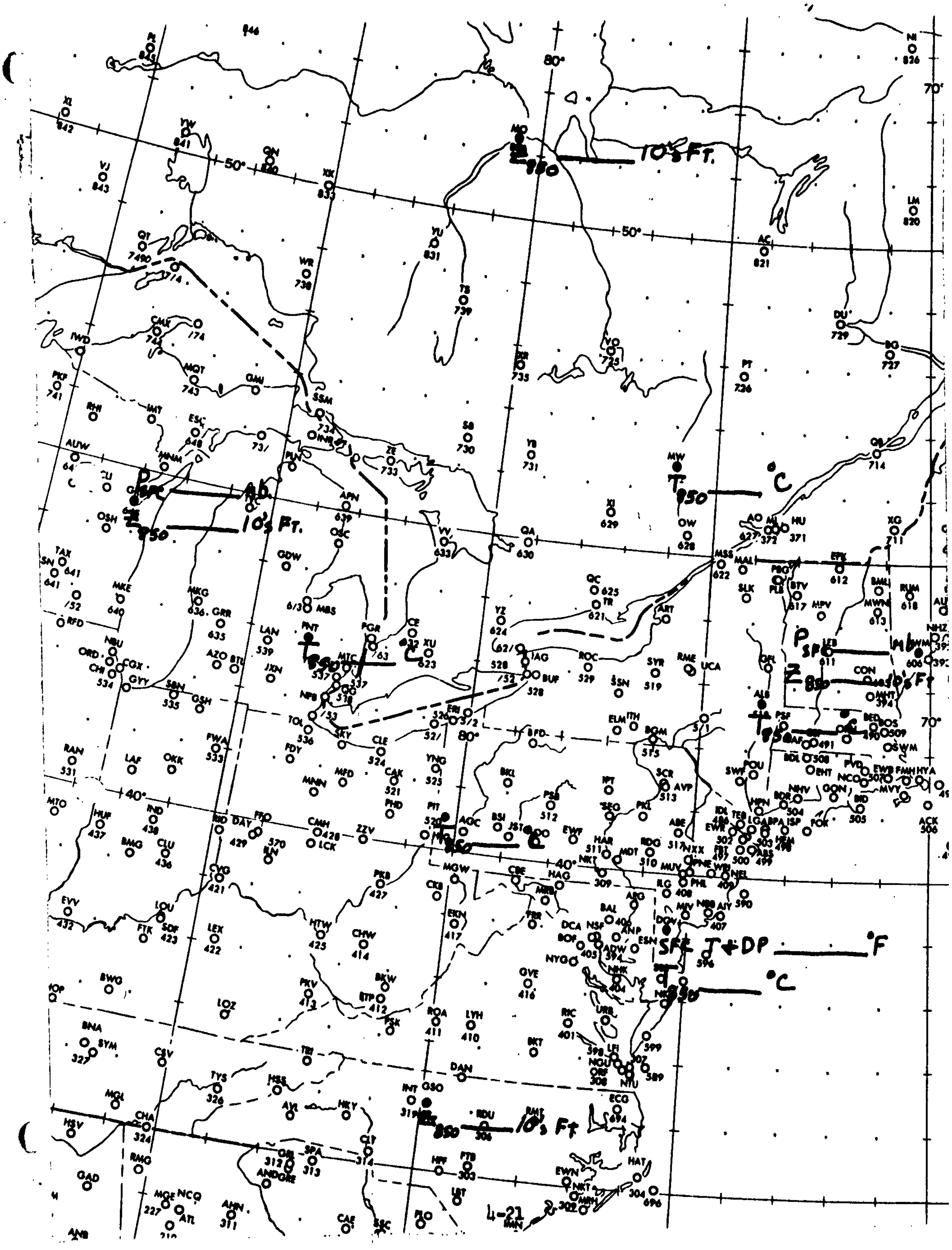
10. Multiply the values obtained in steps (8) and (9). ________

11. Add the values obtained in steps (7) and (10). (Entered in 100's of units) ________

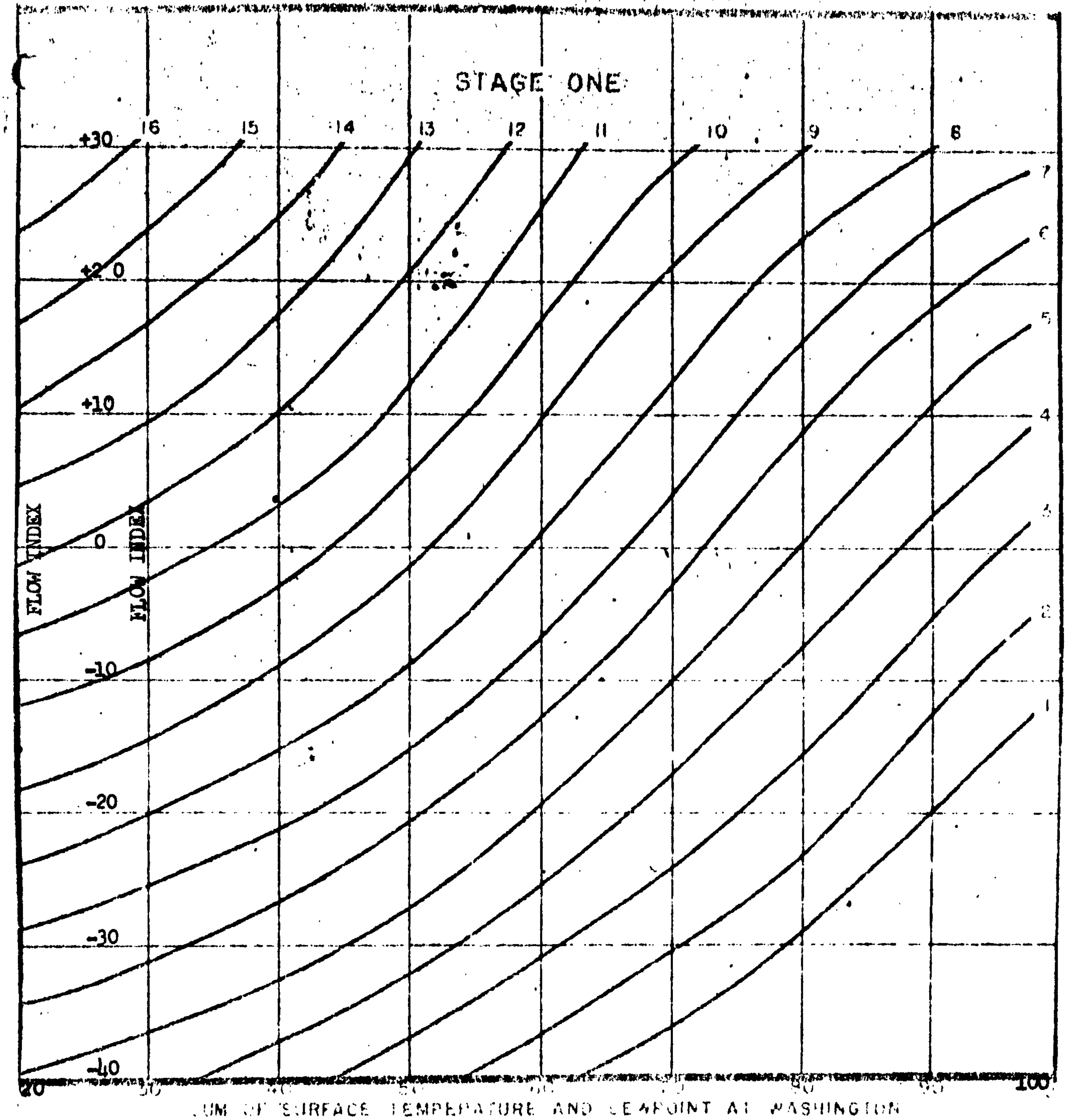
12. Enter the values from steps (4) and (11) in the stage two graphs and record the value indicated by the weight lines. ________

13. Enter the values from steps (3) and (12) in the final graph for the forecast of precipitation type. ________

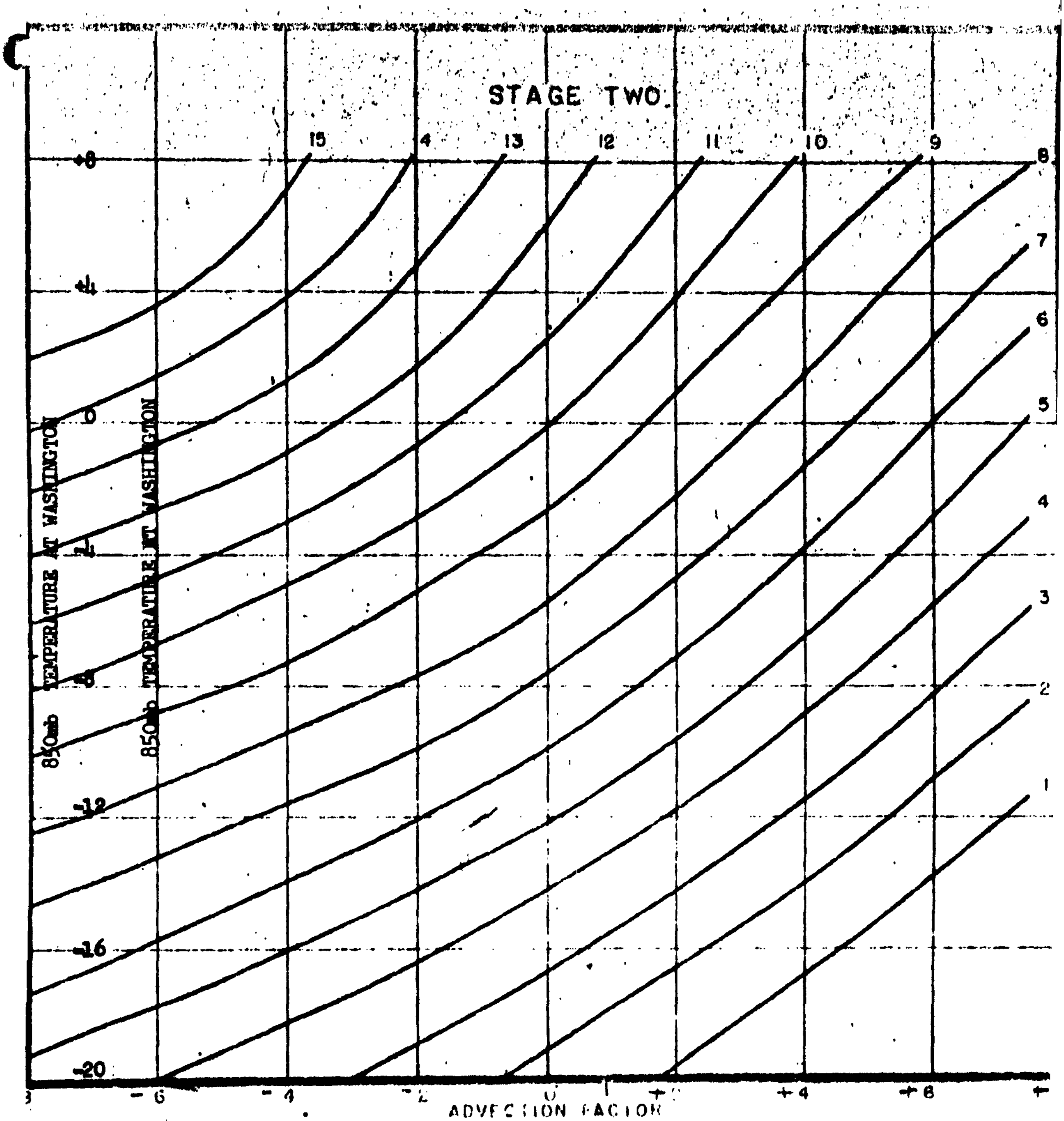
14. To determine the ceiling and visibility forecast, enter the prognostic positions of the surface cyclone on the snow zone chart. ________



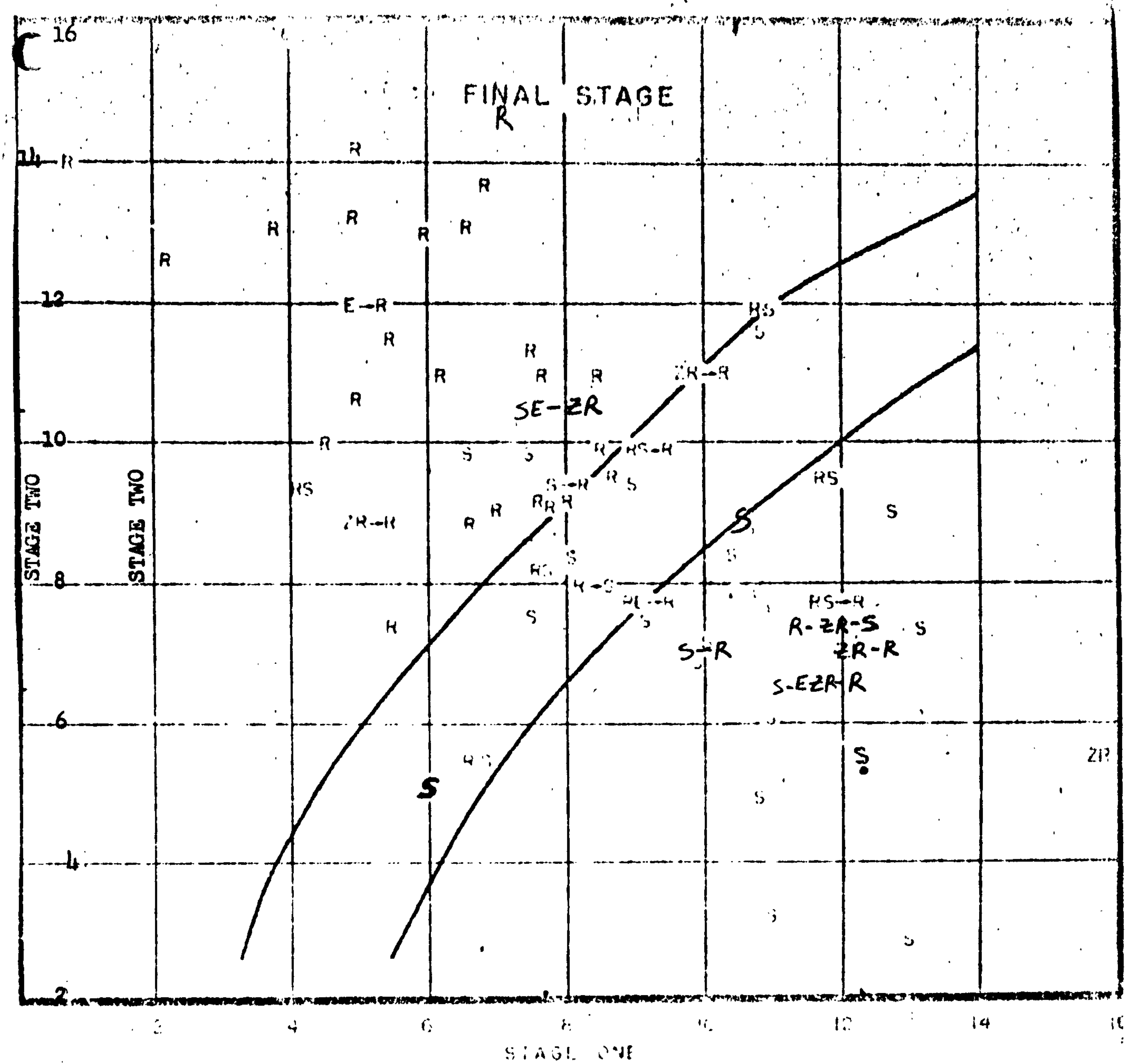
10's FT.
Z_{850}
P SFC ___ Mb
Z_{850} ___ 10's FT.
T_{850} ___ °C
P SFC ___ Mb
Z_{850} ___ 10's Ft
T_{850} ___ °C
SFC T+DP ___ °F
T ___ °C
Z_{850} ___ 10's Ft
50°
80°
70°
40°
4-21



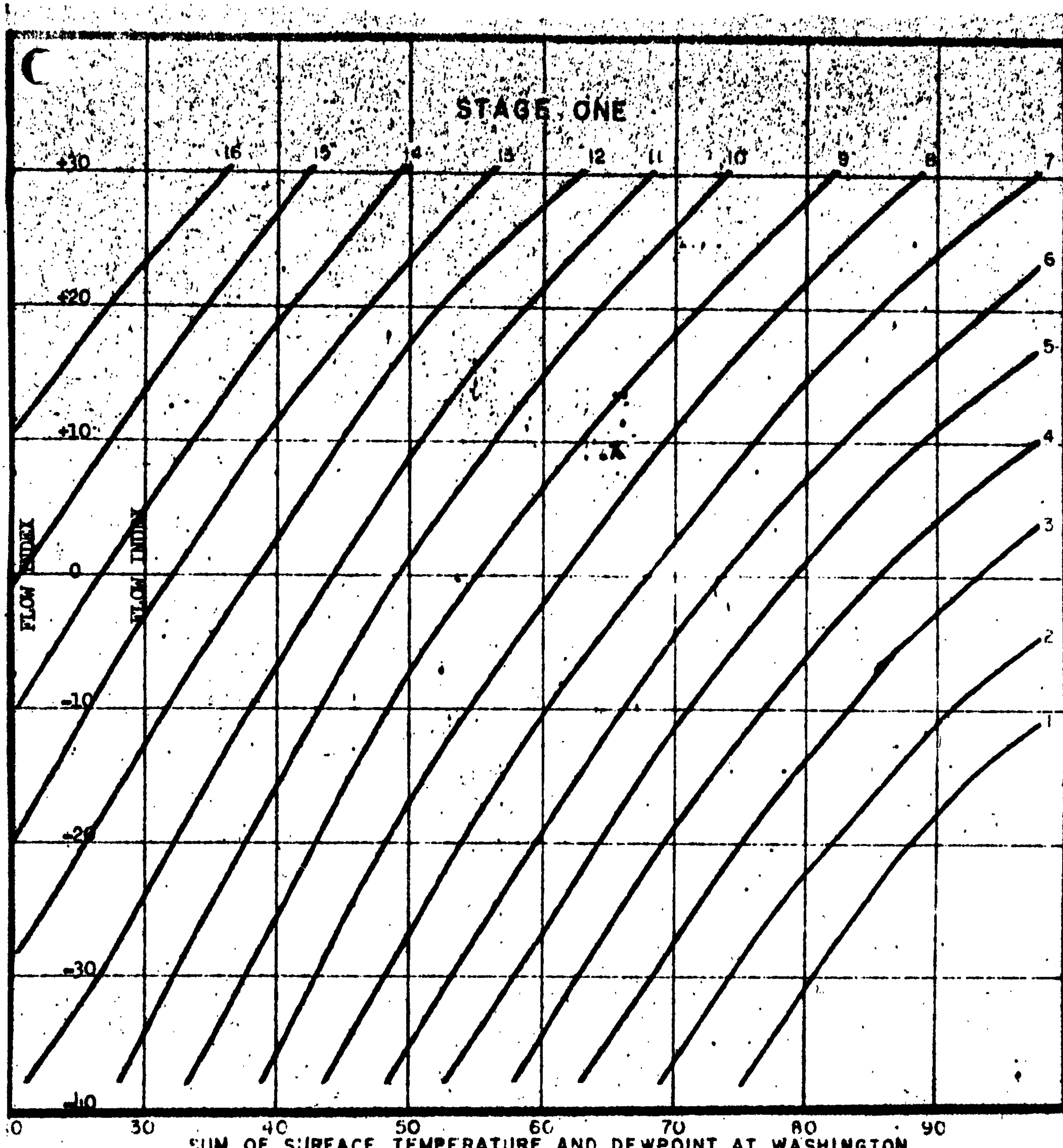
WASHINGTON 24 HOUR GRAPH



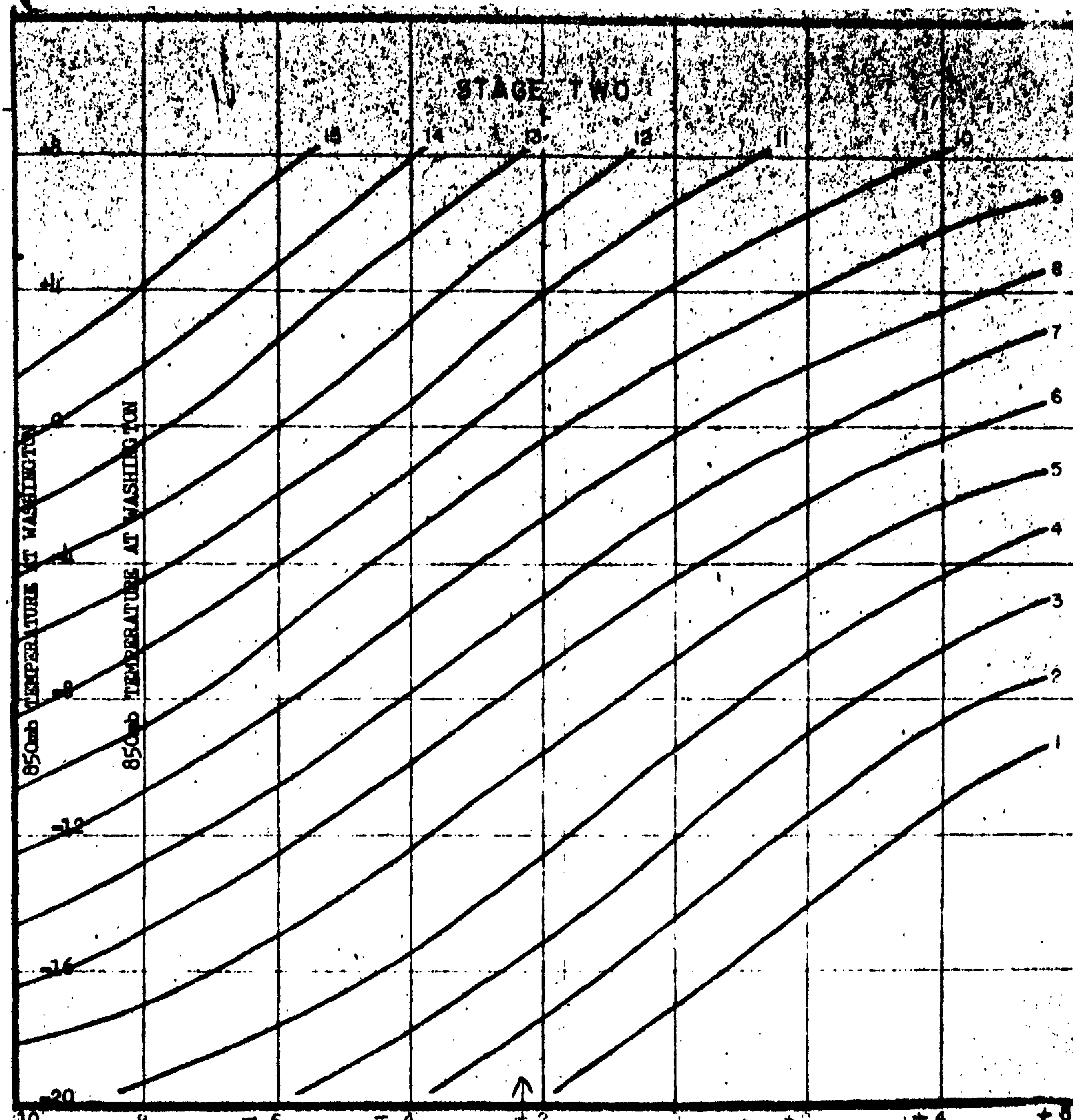
WASHINGTON 24 HOUR GRAPH



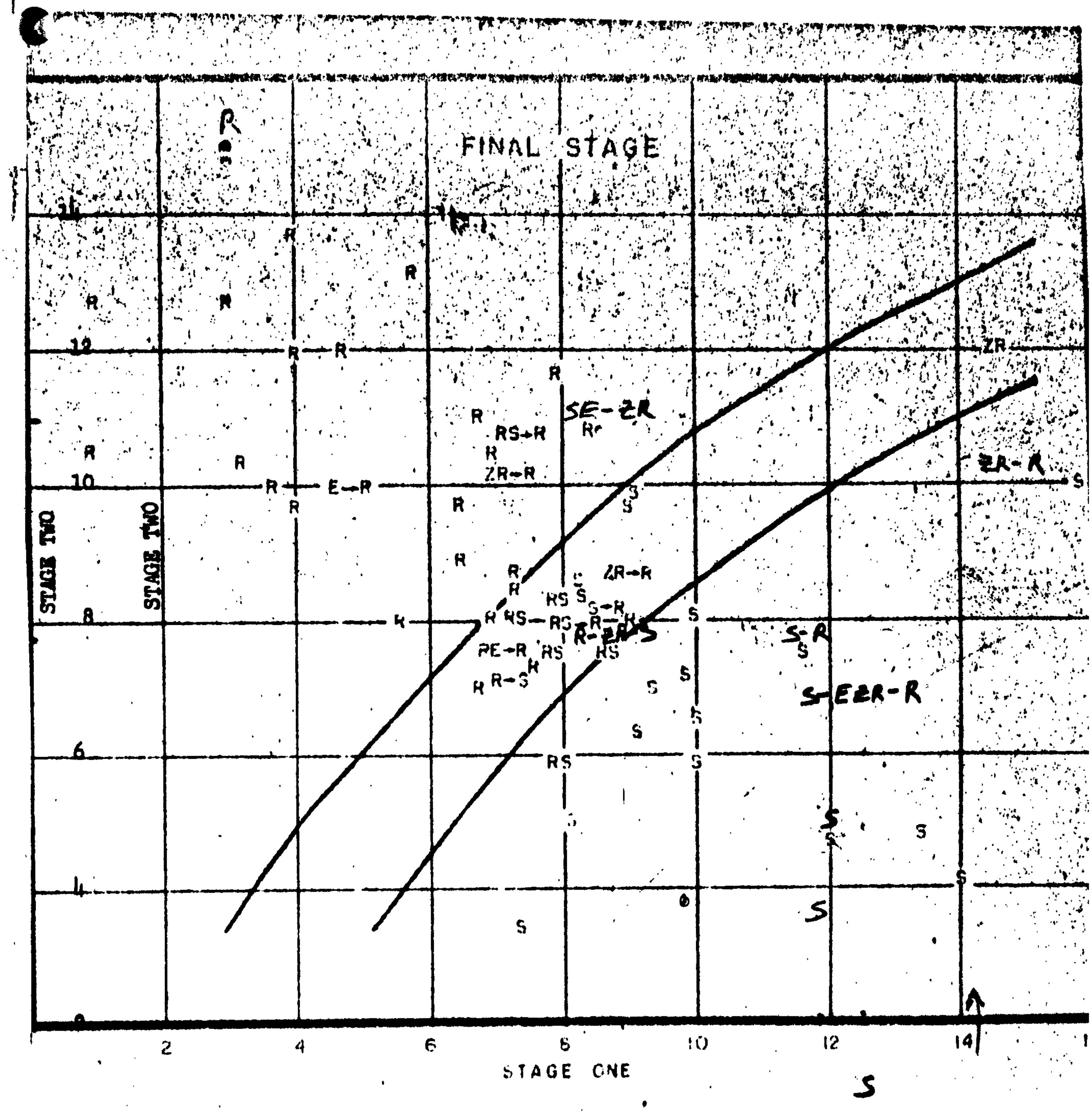
WASHINGTON 24 HOUR GRAPH



WASHINGTON 12 HOUR GRAPH



WASHINGTON 12 HOUR GRAPH



WASHINGTON 12 HOUR GRAPH

Given a situation in which snow will occur, the next step is to predict the intensity of the snowfall. The approach used to determine this feature was based on the duration of low ceilings and visibilities. Specific values of ceilings and visibilities were assigned to heavy moderate and light snow in the following fashion:

1. Heavy snow - ceilings less than 200 feet or visibility less than 1/2 mile.

2. Moderate snow - ceilings 200 feet through 400 feet visibility 1/2 mile up to, but not including 1 mile.

3. Light snow - ceilings 500 feet or higher; visibility 1 mile or better.

The synoptic situations which produce heavy or moderate snow for periods of more than a few hours duration are associated with the passage of a surface cyclone to the south and east of the station involved. The most favorable situation for heavy snow is associated with deep or deepening cyclones. The history of the storm situation falls into the 3 categories mentioned earlier. They were; the Gulf States low moving northeast along the Atlantic Coast, a cyclone forming along the coast and moving northeast and a low from the Ohio Valley moving east into the Atlantic crossing the coast north of Hatteras.

For all such cyclones producing snow at Washington, the ceiling and visibilities were plotted at the position of the low center at six hour intervals as the low moved northward. From these plots was obtained the following chart, which shows that a zone exists in which the ceilings and visibilities indicate heavy snow as defined earlier and a larger area which indicates moderate snow. This chart should be used in conjunction with the prognostic positions of the surface cyclone. The ceilings and visibilities should be forecast in accordance with the positions of the cyclone, relative to the moderate and heavy snow zones. The duration of low ceilings can be predicted from the time of entry to the time of exit from the low ceiling zone. The prediction of moderate snow zone, is based on the predicted time that the surface cyclone will enter and leave the moderate snow zone. The same holds for heavy snow. A suggested value for ceiling and visibility when the low is in the moderate zone, is 300' and 3/4 mile. In the heavy zone, 100' and 1/4 mile, is a suggested value for ceiling and visibility.

Rules of Thumb for snow

<u>850 mb Temp</u>

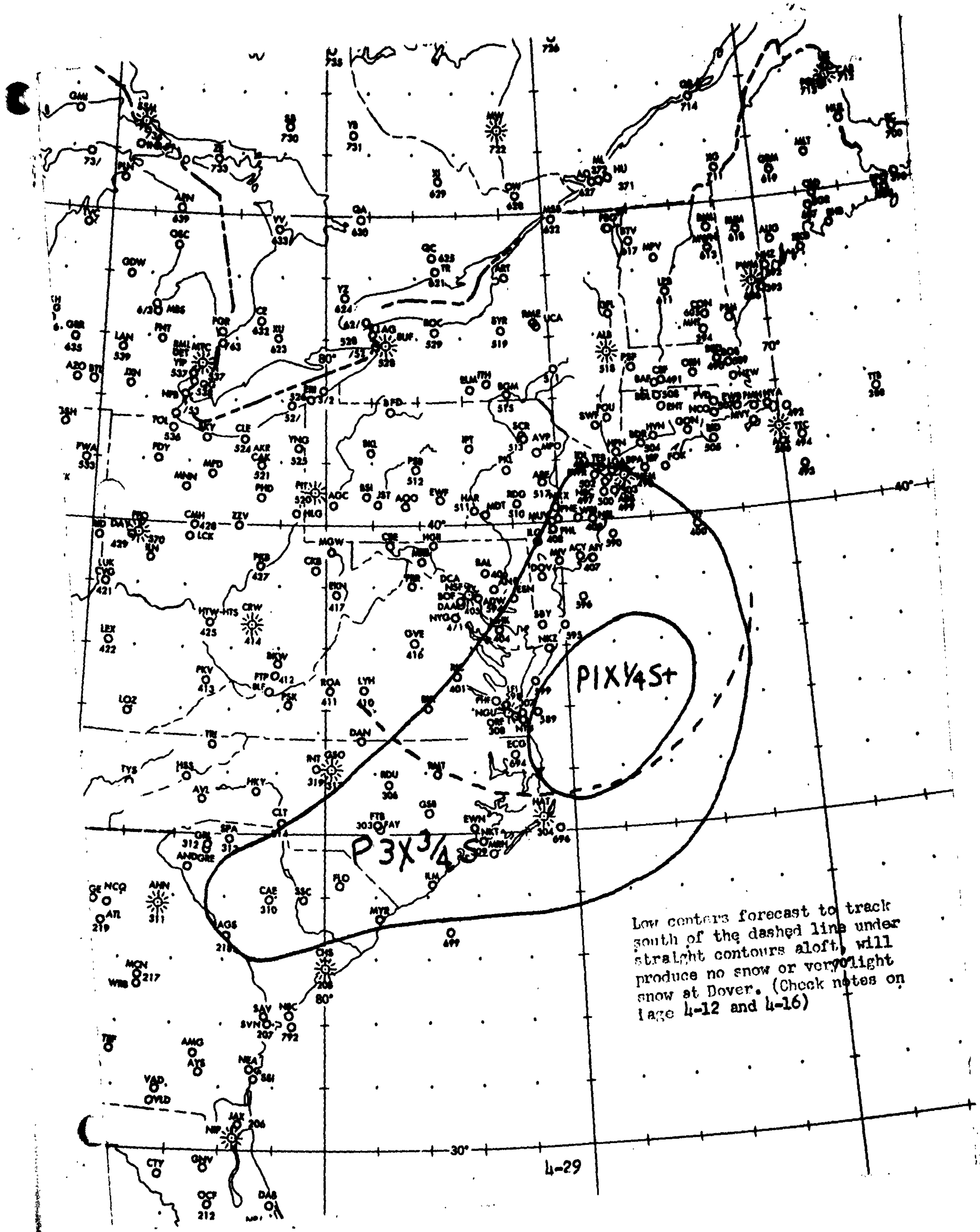
-2°C or less at the start of the precip
-7°C or less 24 hours before precip is to occur

<u>700 mb Temp</u>

-7°C or less at the start of the precip

<u>General Temp</u>

Temp above 900 mb below freezing;
Wet-bulb temp below 900 mb, below freezing.



Low centers forecast to track south of the dashed line under straight contours aloft, will produce no snow or very light snow at Dover. (Check notes on Page 4-12 and 4-16)

1000-500 mb thickness

17900 or greater	10-90 Snow
17800	24-76 "
17700	41-59 "
17400-17600	50-50 "
17300	86-14 "
17200 or less	95-05 "

Cooling

Another important factor is atmospheric cooling by melting snow in lowering the freezing level to the ground. Determine the average $\Delta P \Delta T$ above freezing on the Skew-T Log-P Diagram. Then to determine the amount of liquid precip needed to lower the freezing level to the surface, use the following equation:

$$X = \frac{\Delta P \Delta T}{500}$$

Amount of Snow

1. Determine the difference of mixing ratio in gm/kg between the base and top of the moist layer. 0.02 in/hr of liquid precip will occur for each gm/kg of moisture precipitated by cooling. Determine the product.

2. Multiply this value by the number of hrs that precip is forecasted. This gives you the total liquid precip.

3. Multiply this result by 10 to obtain the snow depth.

References:
"Weather Forecasting for Aeronautics" by J. J. George
"An Analogue Method for Forecasting Heavy Snows at Washington, New York and Boston" by A.H. Stakely and R.M. Whiting

D. SPECIAL SYNOPTIC STUDIES:

A case study of a "back-door" cold front followed by an extended period of low ceilings and visibilities.

1. Synoptic Situation: At 1200Z on 29 April 1962 a weak stationary front was oriented East-West from the central New England states thence southwestward as a warm front through Illinois, Missouri and into a low pressure area in Kansas. An occluded front extended northward from this low pressure center. The 500-MB chart was characterized by southwesterly flow over most of the U.S. with a major trough over the Rockies. The major ridge was located just off the east coast of the U.S.

By 1200Z 30 April 1962, the occluded front had progressed to central Wisconsin and Iowa, while the stationary front over New England had moved southward as a cold front to a line along eastern Pennsylvania and southern New Jersey. This was due to the building of the upper ridge over eastern U.S. with a corresponding increase in the intensity of the surface ridge over the Newfoundland area. This so-called "back-door" cold front continued to move southward along the eastern seaboard in response to the persistent northerly flow aloft at the 500-MB level.

By 1200Z 2 May 1962, the cold front was oriented along a line from Norfolk to Gordonsville to Martinsburg. It remained quasi-stationary in this approximate position until near 0600Z on 3 May 1962, at which time the occluded front from the west moved through the area and off the coast.

Figures 1 through 9 show the composite surface and 500-MB patterns during this period. Surface observations for a number of stations along the coastal area are depicted in Figures 10 and 11. The passage of the cold front is readily apparent at all stations. Figure 12 illustrates the daily movement of the cold front through the period 0600Z on 1 May 1962.

2. Surface Weather Pattern: An extended period of low ceilings and poor visibilities prevailed at all stations following the passage of the cold front. Ceilings varied from zero to 800 feet with visibilities 1/8 to 4 miles. At Dover, ceilings below 800 feet prevailed for some 85 hours.

3. Conclusions: This pattern is a typical one for the eastern seaboard and Dover Air Force Base. The basic pattern may evolve in two ways. One is described here. The other evolves from a normal cold front which passes the Dover area and after becoming quasi-stationary over the central Gulf coast states, returns as a warm front and becomes imbedded in the Appalachian Mountains with a north-south orientation. A cold dome of air persists over the Piedmont plains and coastal area thus blocking the warm front and causing it to remain stationary in the mountains.

In either case, the results are the same: extensive low ceilings and poor visibilities prevail at most stations located within the cold air mass. The forecaster must guard against prematurely predicting the passage of the warm front. He must be guided by the existing and predicted 500-MB flow pattern. The presistence of the ridge aloft over the eastern seaboard, as characterized by northerly winds over or just off the east coast, is the prime indicator which alerts the forecaster to the fact that the surface high will remain quasi-stationary and dominate the coastal area. (Note that in Figure 9, the surface ridge has also blocked the occluded front resulting in a bent-back occlusion.) An occluded front from the west will eventually push its way to the coast resulting in clearing conditions at Dover. In all cases, this occluded front is a Pacific front (warm front type occlusion) and results in warmer temperatures.

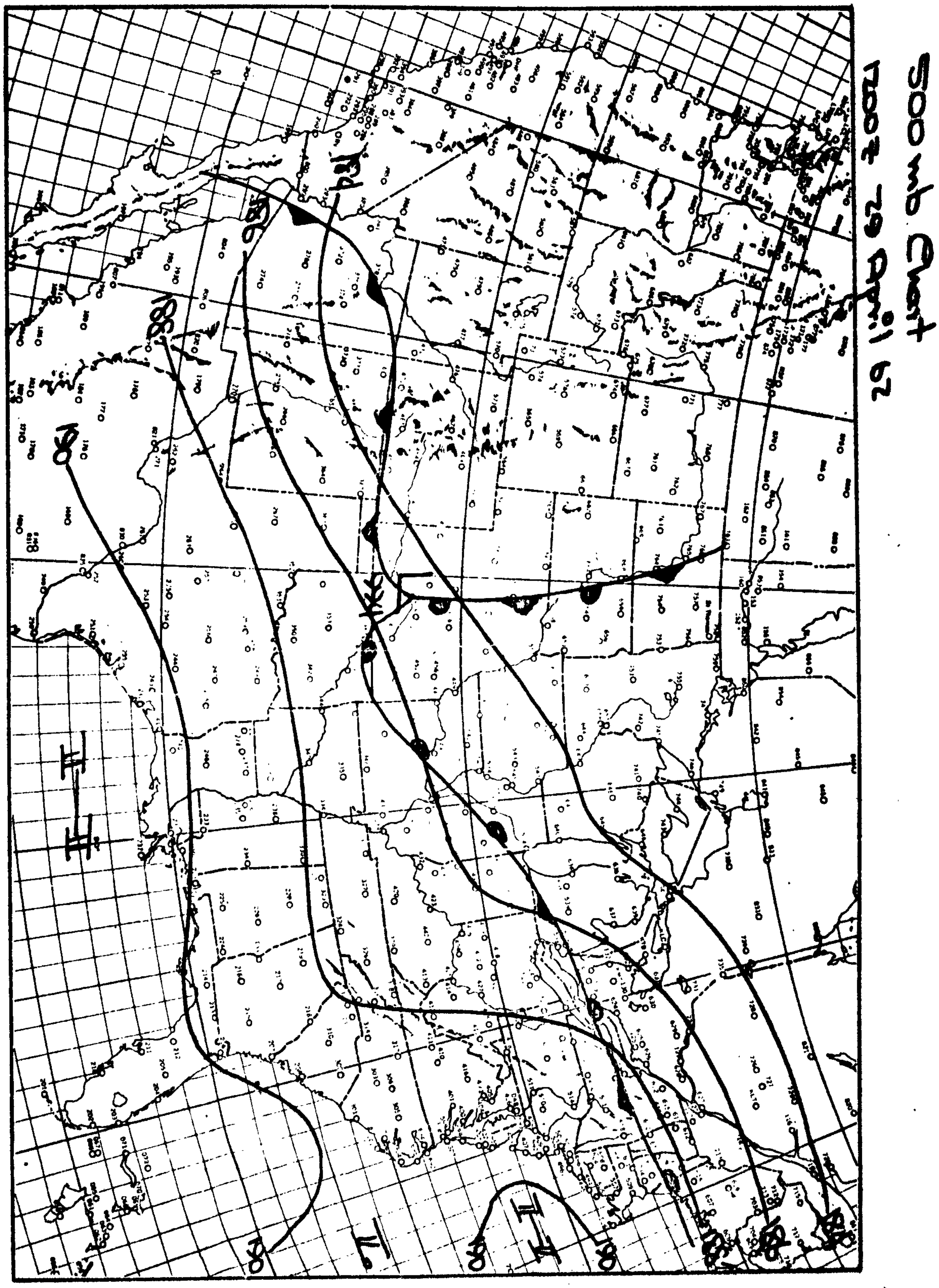


Figure 1

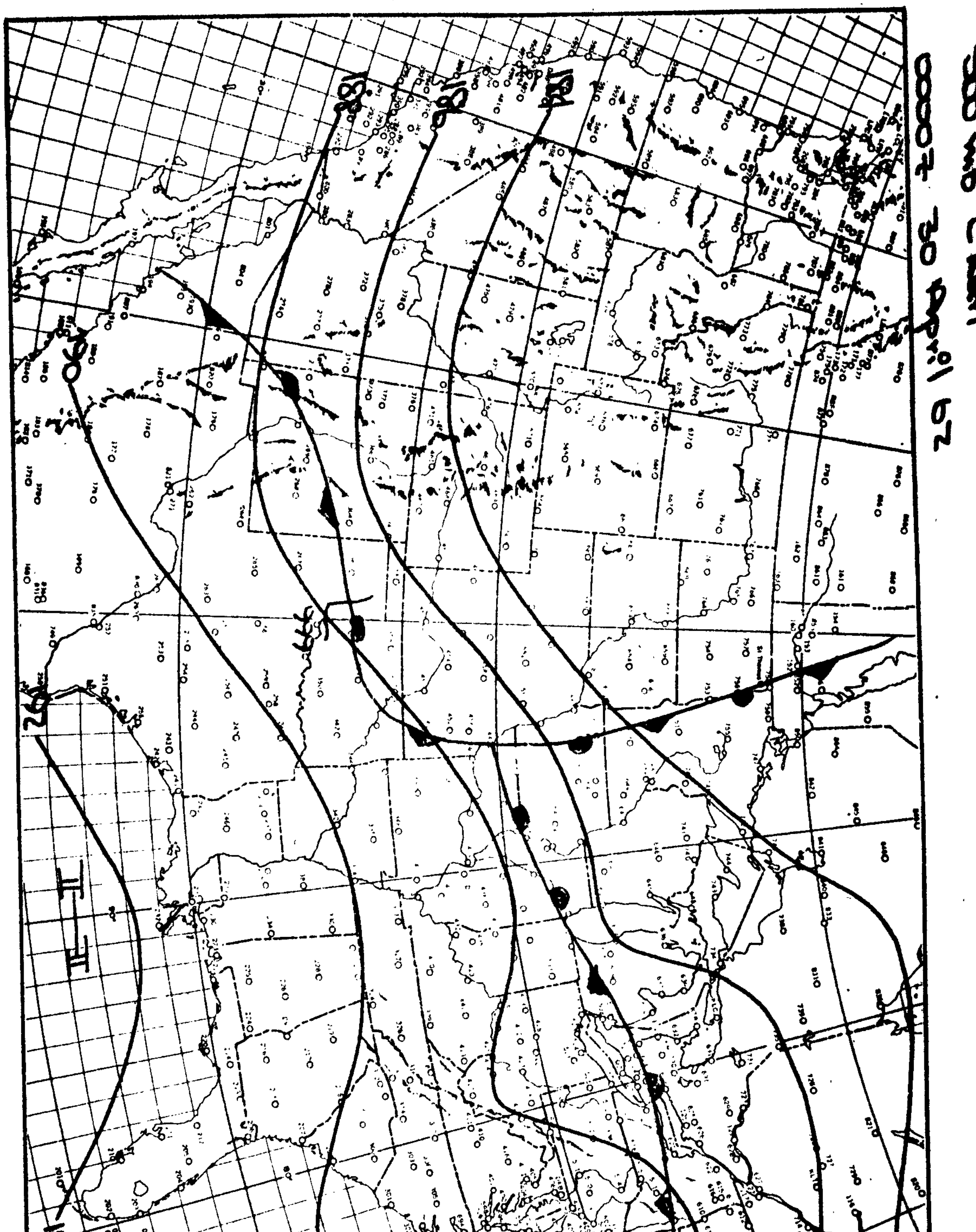


Figure 2

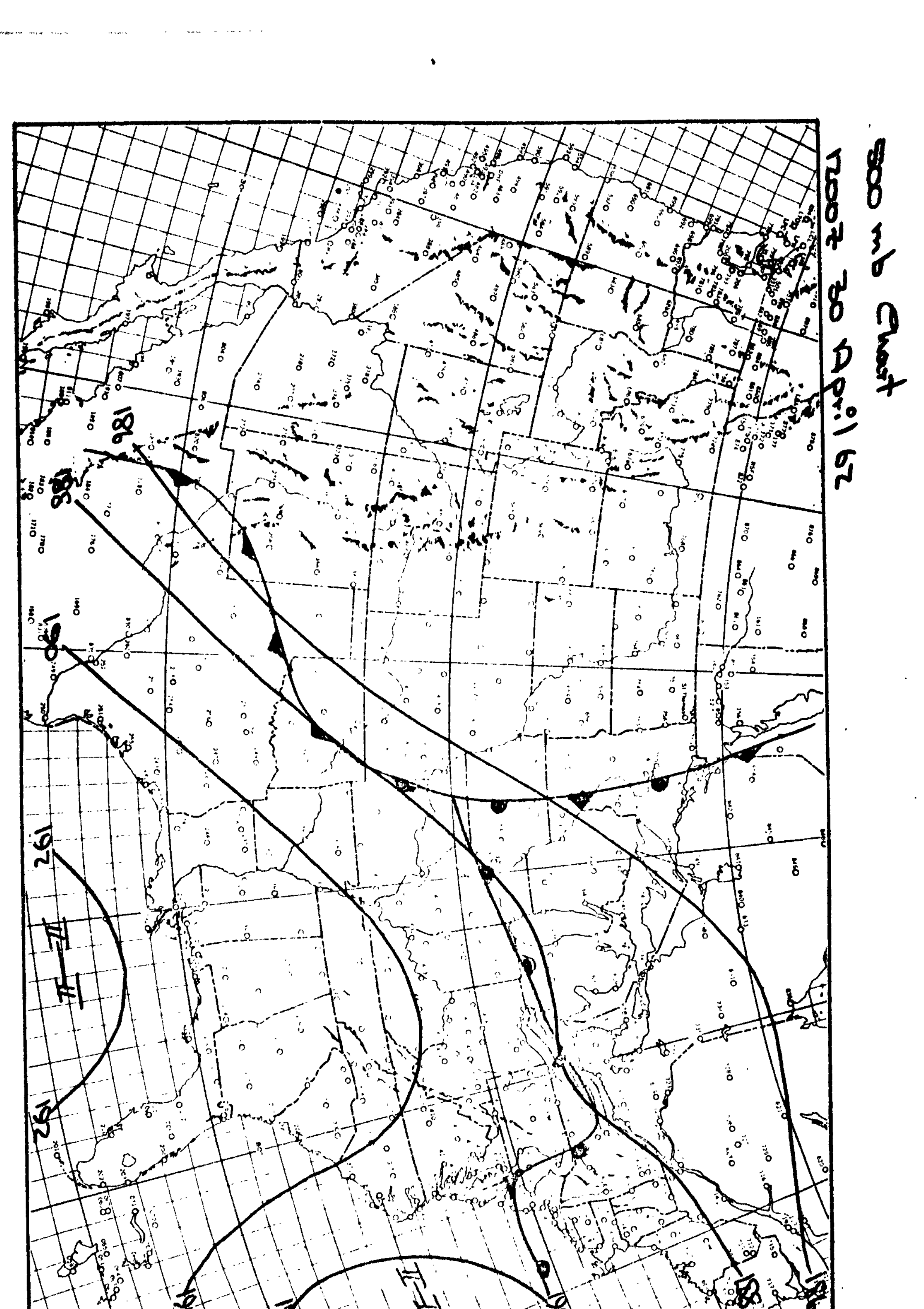


Figure 3

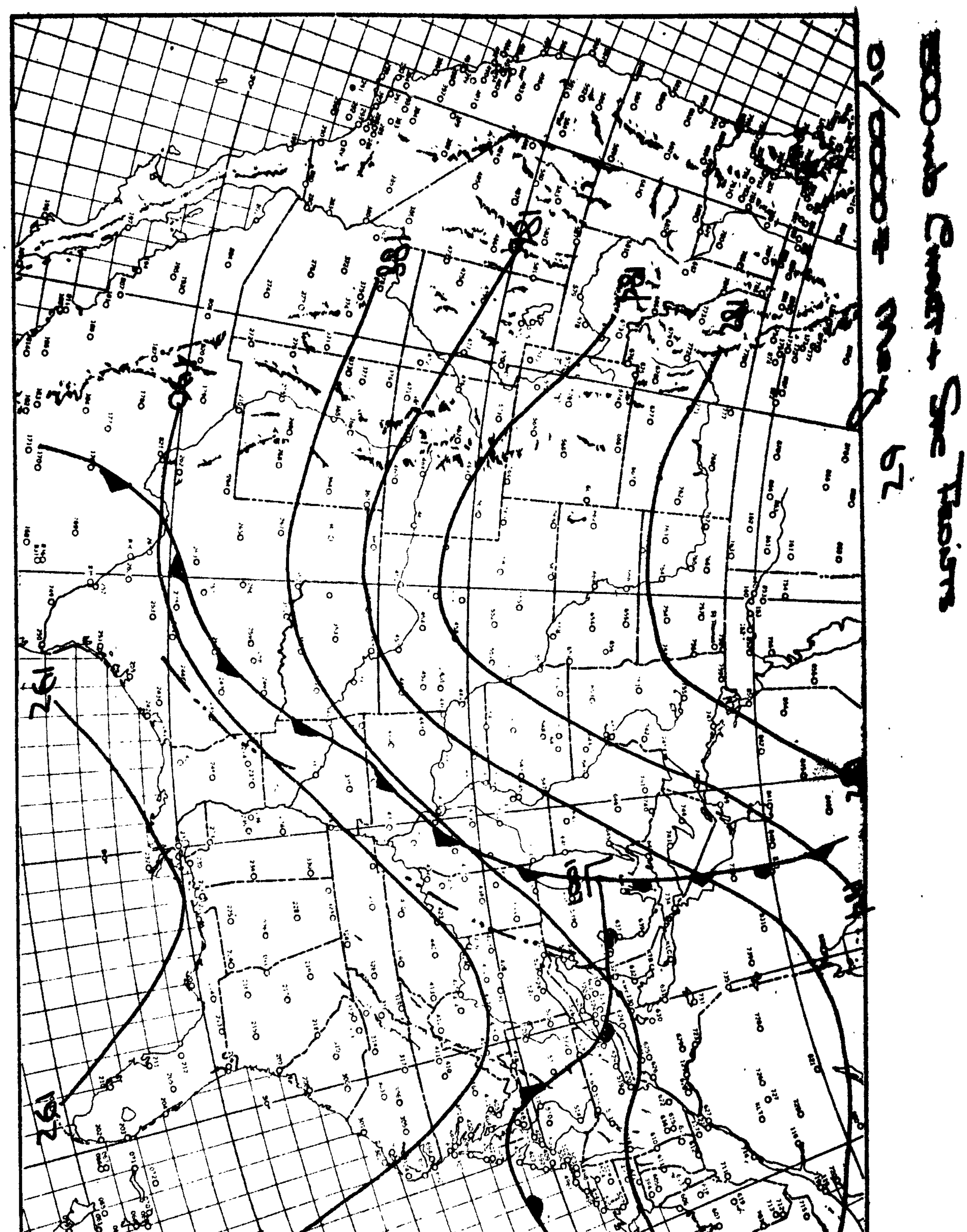
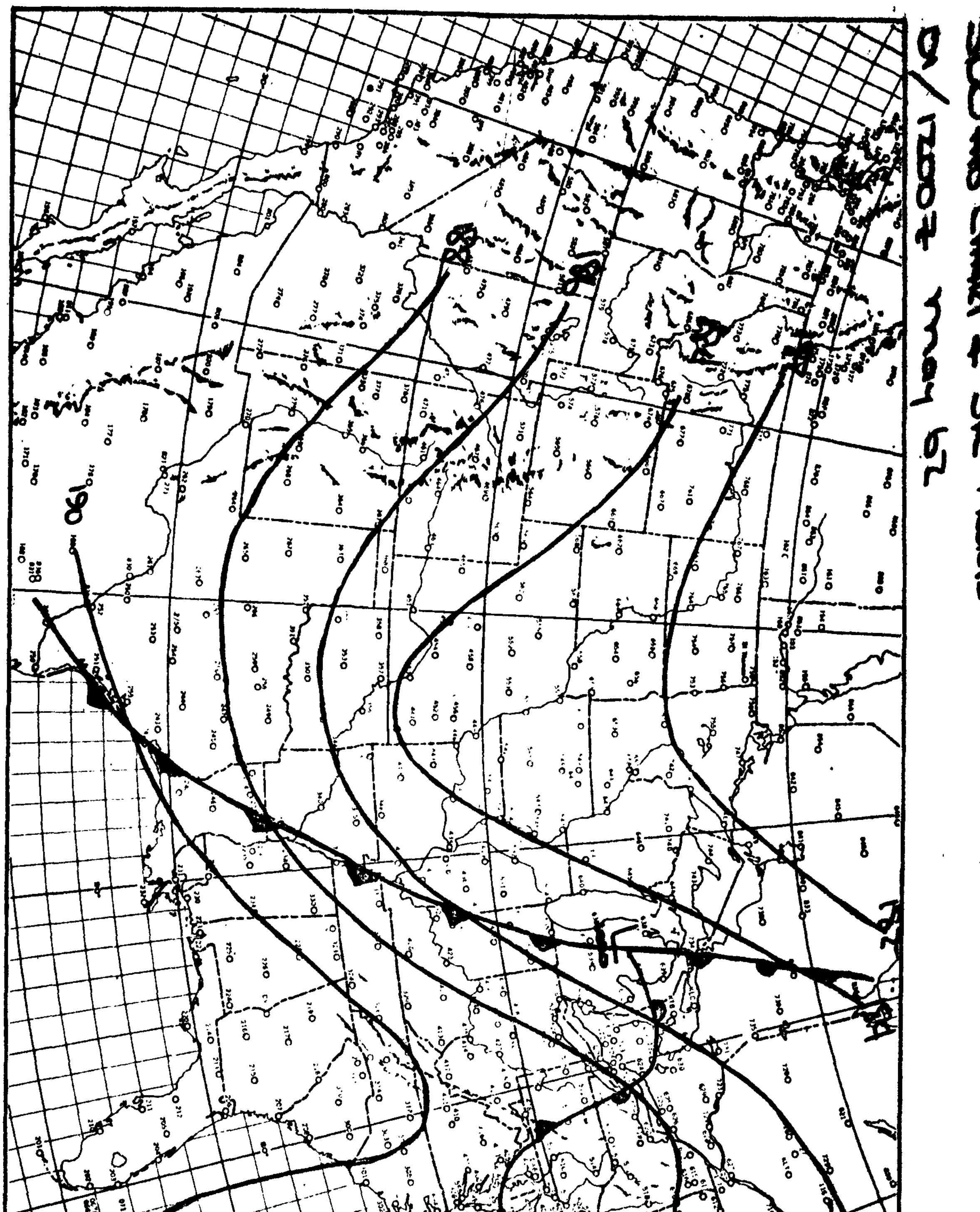


Figure 4



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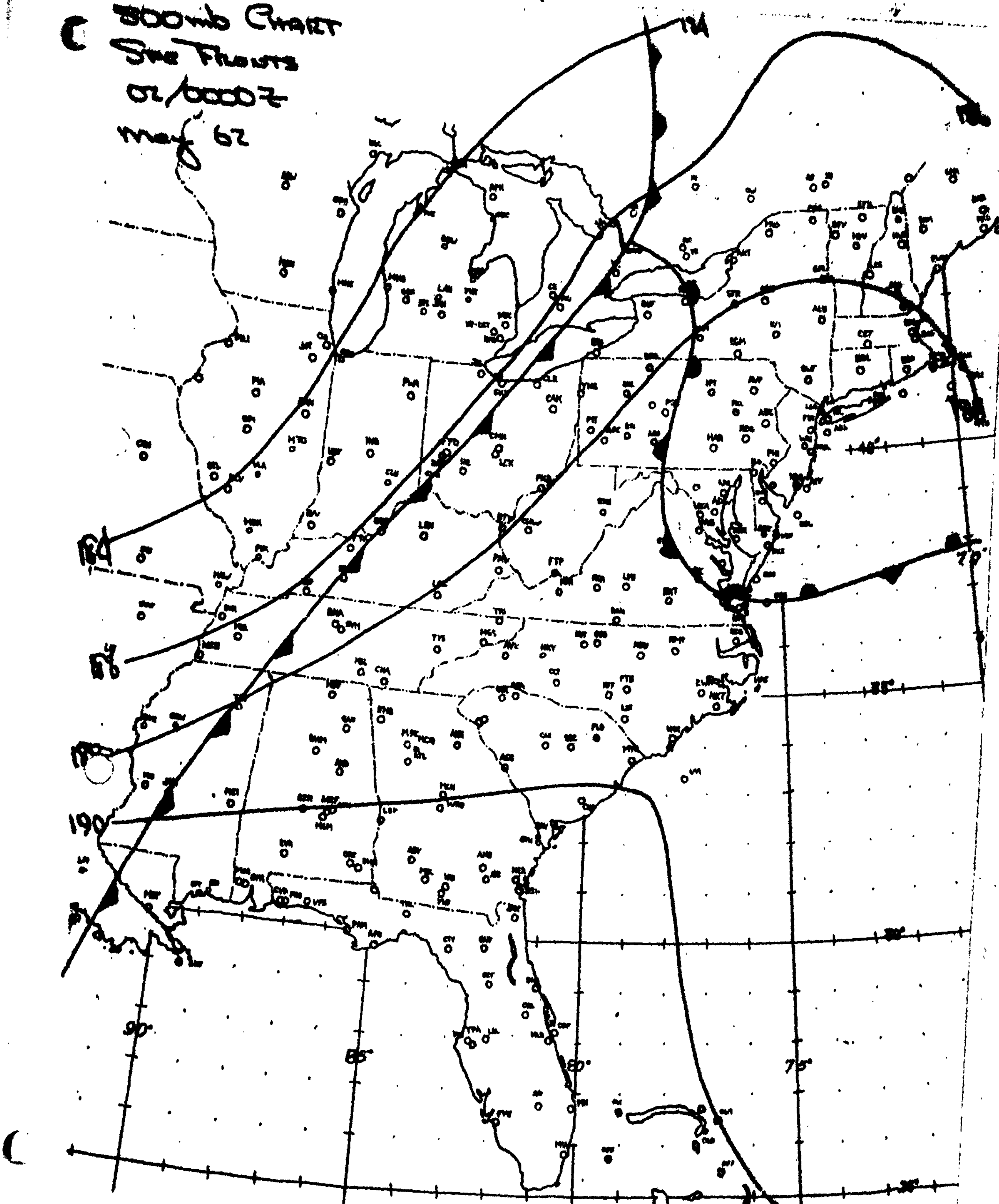
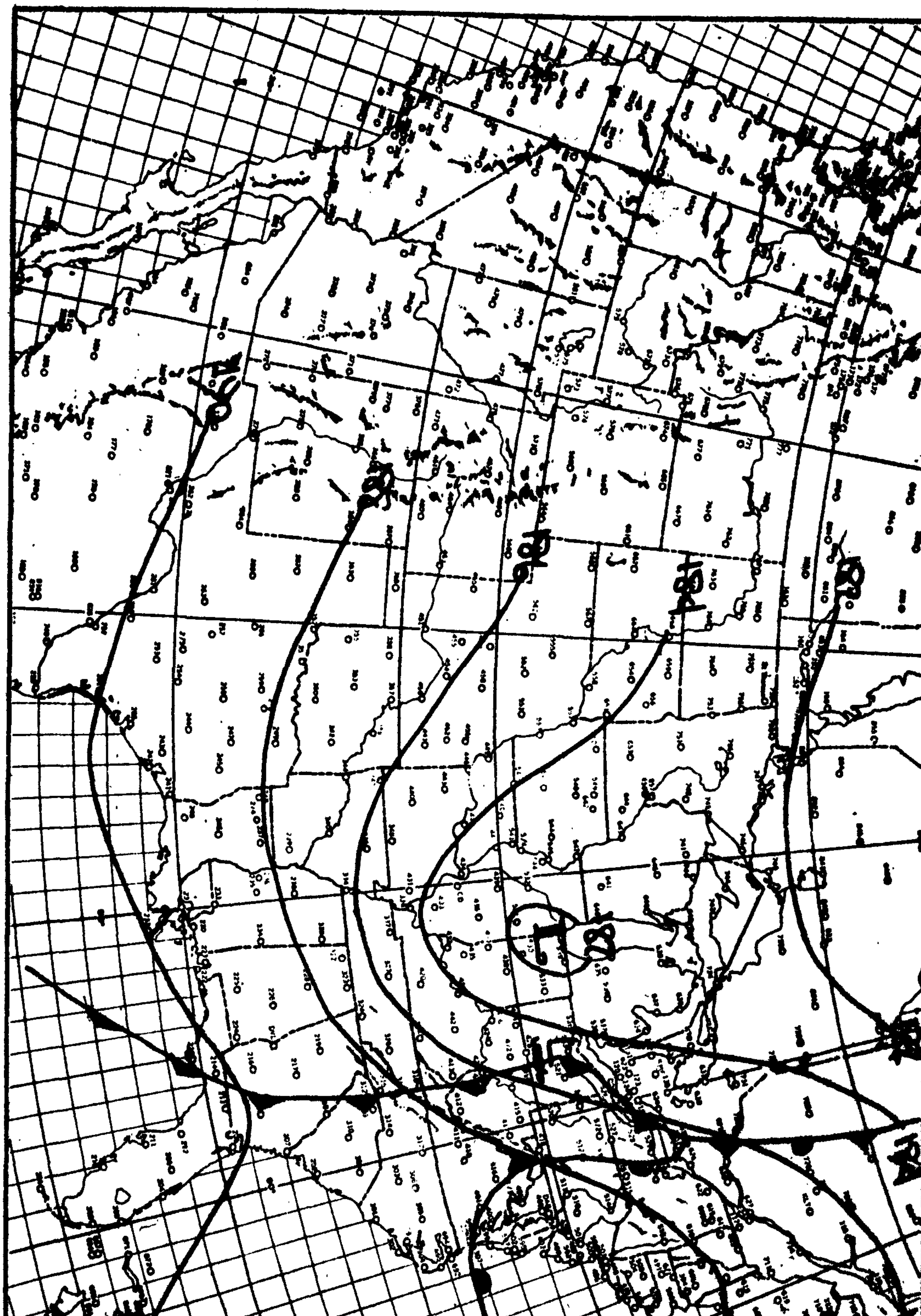

300mb Chart
Sfc Fronts
02/0000Z
May 62
174
186
184
186
190
190
190
40°
35°
30°
25°
90°
85°
80°
75°
70°

Figure 6



500mb Chart + Sfc Fronts
07/1200Z May 67

Figure 7

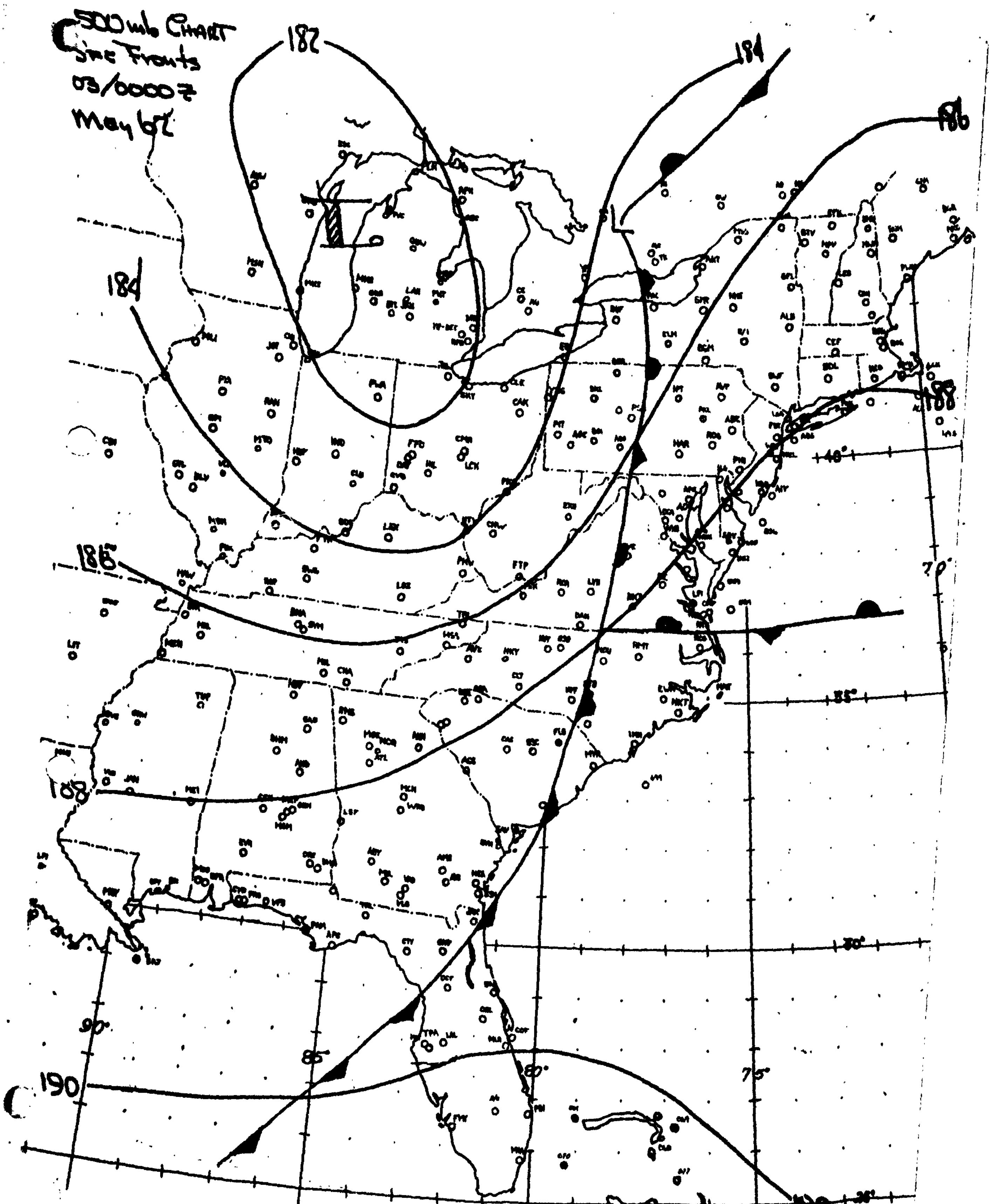

500 mb CHART
Sfc Fronts
03/0000Z
May 67
182
184
186
188
190
90°
85°
80°
75°
70°
40°
35°
30°
25°

Figure 8
4-40

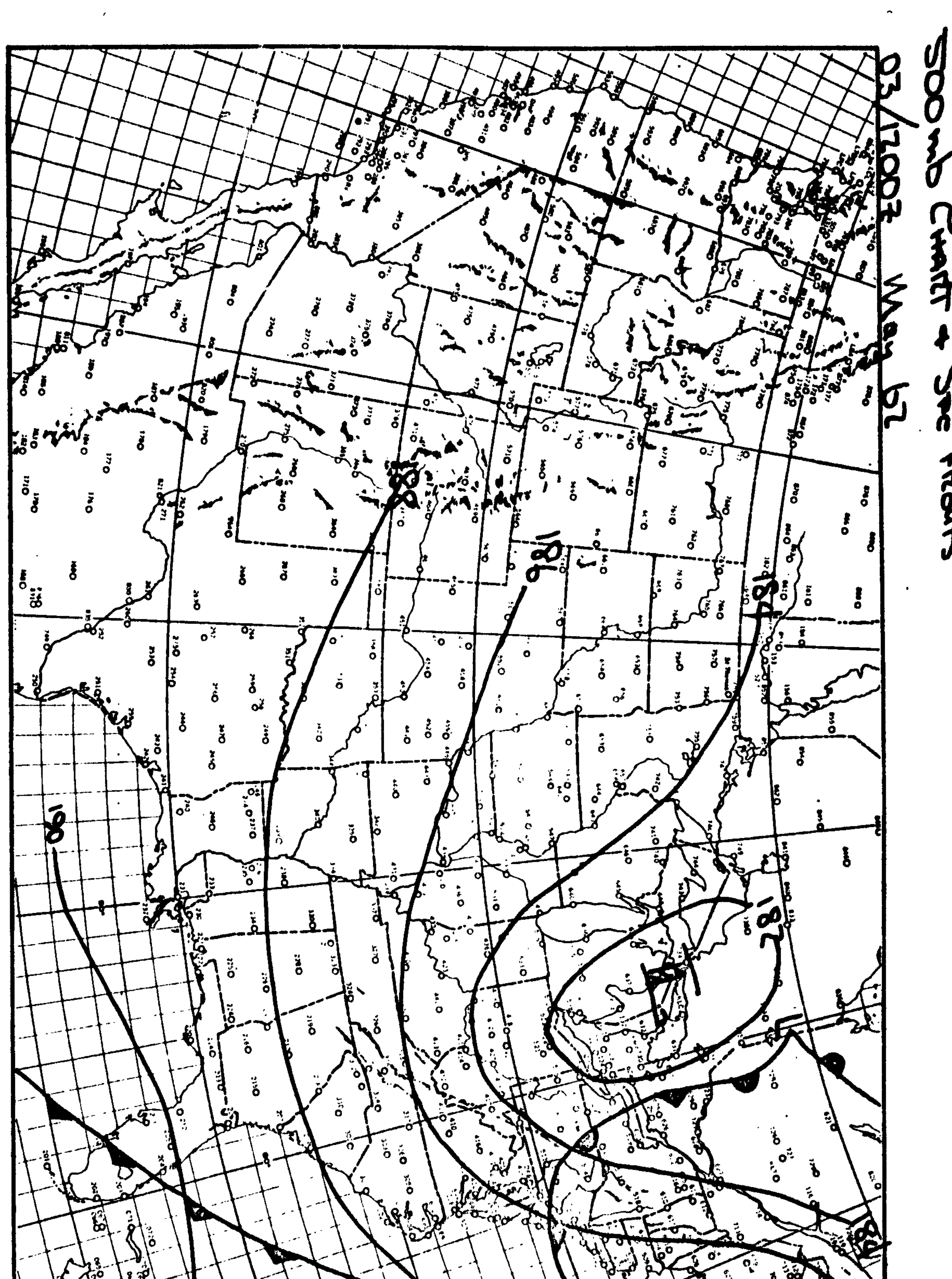


Figure 9

Figure 10

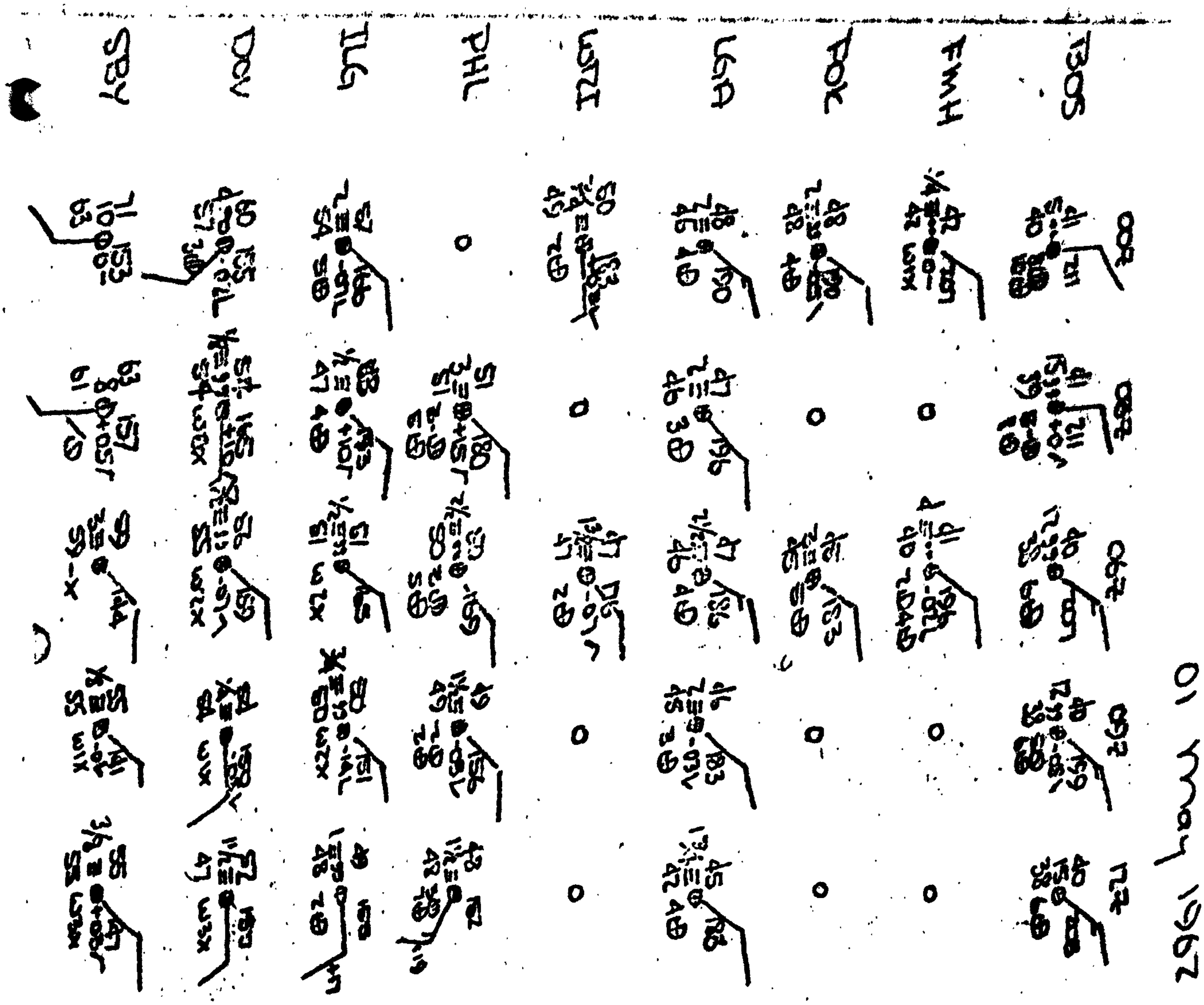


Figure 11

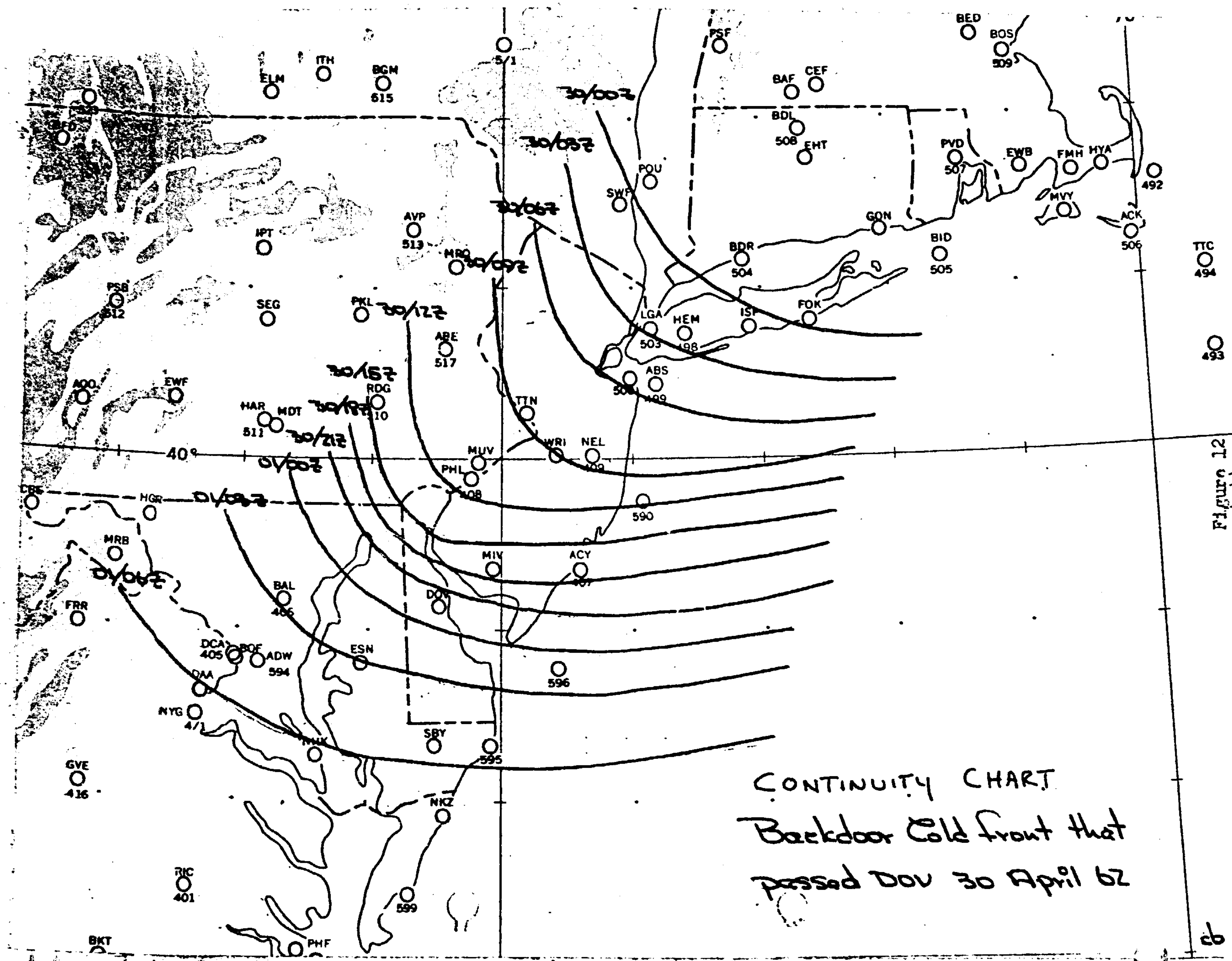


Figure 12
4-44

E. EMPIRICAL RULES:

Rule 1. Do not forecast a minimum temperature below 14°F if there is no snow cover on the ground.

Rule 2. $\text{Minimum Temp} = \dfrac{\text{Max Temp} + \text{Dew Point (at time of Max Temp)} - 12}{2}$

Rule 3. If temperature at 700 mb is -8°C or colder forecast snow; if less than -7°C, forecast rain; if -7°C, rain and snow mixed. (Use as first approximation only - Temps must be forecast)

Rule 4. If 1000-500 mb thickness is 17,600 feet or less, forecast snow; above 17600 feet, forecast rain.

Rule 5. If strong gusty surface winds (25K+) are expected in advance of a deepening low along the coast, forecast rain. If snow does begin, forecast one inch or less with snow changing to rain. Exception: If surface winds are N-NE, forecast snow. Amount will depend on speed of movement of storm center.

Rule 6. Do not forecast post-frontal snow showers unless 700-mb Trough is west of Dover. (Very reliable)

Rule 7. Light SE Flow and clear skies - very favorable for fog in Fall and Winter. (First approximation)

Rule 8. (a) SE winds with Dew point temperature below (ocean) water temperature: Fog unlikely (all seasons)

(b) SE winds with Dew point temperature above water temperature: Fog likely (all seasons)

Rule 9. With clear skies, high dew point temperatures and light southwesterly surface winds, forecast ground fog at about sunrise. (Visibilities below 1/2 mile possible, but will last for less than 1 hour.)

Rule 10. Below GCA conditions prevail (less than 200 feet and/or 1/2 mile visibility) and winds are calm or light from south or easterly direction: Forecast above GCA conditions 1 - 2 hours after wind shifts to southwest or westerly direction. (Very reliable for short range period.)

Rule 11. Fall, Winter and Spring: If scattered clouds form below 2000 feet near sunrise, forecast a ceiling by 0900L. (Ceiling will remain broken and persist till noon.)

Rule 12. Behind slow moving "back door" cold front, forecast reduced visibilities in Haze.

Empirical Rules (Continued)

Rule 13. If cloud cover and light precipitation prevail during daylight hours (or if considerable precipitation has fallen during the past 24 hours) in advance of a slow moving cold front which is expected passes Dover near sunset, resulting in clearing, then forecast heavy ground fog for a period of 1-3 hours after clearing occurs.

Rule 14. With a weak surface low over Virginia at 1500 EST and southwesterly flow aloft, forecast thunderstorms over Delaware in the late evening. (Summer season)

Rule 15. Thunderstorms which form over the Delmarva peninsula, build rapidly and are generally stronger when passing over Dover than thunderstorms which form west of the Chesapeake Bay.